Fatigue Behavior of Modified Asphalt Concrete Pavement

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ABSTRACT

Fatigue cracking is the most common distress in road pavement. It is mainly due to the increase in the number of load repetition of vehicles, particularly those with high axle loads, and to the environmental conditions. In this study, four-point bending beam fatigue testing has been used for control and modified mixture under various micro strain levels of (250 µƐ, 400 µƐ, and 750 µƐ) and 5*HZ*. The main objective of the study is to provide a comparative evaluation of pavement resistance to the phenomenon of fatigue cracking between modified asphalt concrete and conventional asphalt concrete mixes (under the influence of three percentage of Silica fumes 1%, 2%, 3% by the weight of asphalt content), and (changing in the percentage of asphalt content) by (0.5% ±) from the optimum. The results show that when Silica fumes content was 1%, the fatigue life increases by 17%, and it increases by 46% when Silica fumes content increases to 2%, and that fatigue life increases to 34 % when Silica fumes content increases to 3% as compared with control mixture at (250 µƐ, 20°C and optimum asphalt content). From the results above, we can conclude the optimum Silica fumes content was 2%. When the asphalt content was 4.4%, the fatigue life has increased with the use of silica fumes by (50%), when asphalt content was 5.4%, the additives had led to increasing the fatigue life by (69%), as compared with the conventional asphalt concrete pavement.

Key words: asphalt concrete, silica fumes, asphalt cement, fatigue life

تصرف الكلال في رصفة الخرسانه الاسفلتيه المحسنه

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الخلاصه

تشققات الكلال تعتبر الاكثر شيوعا في الطرق الاسفلتيه. والسبب الاساسي في حدوث هذه المشكله هو الزياده الكبيرة في عدد المركبات وعدد مرات تكرار الحمال مصحوبه بزياده الاحمال المحورية ايضا, والضروف البيئيه. في هذه الدراسة، تم استخدام فحص four-point bending beam fatigue لتقييم خلطة الخرسانة الإسفلتية المعدلة والاعتيادية تحت تأثير مستوى انفعال متغير (250 µƐ, 400 µƐ, 750 µƐ) و5*HZ*. ان الهدف الرئيسي من الدراسة هو مقارنه تقييميه لمقاومة ظاهرة الكلال بين الرصفة المحسنة والرصفة الاعتيادية تحت تأثير ثلاث نسب من ابخرة السيليكا (3%,2%,1% كنسبه من وزن الاسفلت الاسمنتي)، وتغير نسبه الاسفلت بمقدار (±0,5) عن النسبة المثلى. النتائج بينت انه عندما كانت نسبه ابخرة السيليكا 1% زاد عمر الرصفة بمقدار 17%, و زاد عمر الرصفة بمقدار46% عندما زادت نسبه ابخرة السيليكا بمقدار2%, وزاد عمر التبليط بمقدار 34% عندما زادت نسبه نسبه ابخرة السيليكا الى 3%,(250 µƐ, 20°C) عند نسبة الاسفلت المثالية. ومن النتائج اعلاه تبين ان النسبه المثاليه لاضافه ماده ابخرة السيلكا هو2%. وعندما كانت نسبه الاسفلت 4.4% قل عمر التبليط بمقدار 50%, وعنما زادت نسبه الاسفلت الى 5,4% قل عمر التبليط بمقدار69%, مقارنه مع الاسفلت الاعتيادي تحت تأثير نفس الضروف.

الكلمات الرئيسيه : الخرسانة الاسفلتية، ابخرة السيليكا, الاسفلت الاسمنتي, الكلال.

1. INTRODUCTION

Several distresses hamper the performance of flexible pavements in Iraq and result in premature failure. In flexible pavements, the primary forms of distress are fatigue cracking, rutting, and thermal cracking. These distresses manifest themselves most of the time due to construction, material quality, bad maintenance, and incongruous design. Fatigue cracking, called alligator cracking and associated with repetitive traffic loading, is considered to be one of the most significant distress modes in flexible pavements. The fatigue life of an asphalt pavement is directly related to various engineering properties of typical hot mix asphalt (HMA). It is mainly due to the increase in the number of load repetition of vehicle particularly those with high axle loads, and to the environmental conditions. The construction practice and design short comings may also results in shortening of pavement's life and increase maintenance cost as well as road user cost. It is vital to find out ways to delay the asphalt pavement deterioration and increase its service life, **Moghaddam et al., 2011. Miller and Bellinger, 2003,** presented pavement distresses and failure mechanisms in Highway Pavement in their Distress Identification Manual (HPDIM), it was stated that to minimize asphalt concrete pavements distress there are several ways, which could extent pavement service life:

- Produce a new binder type with better physical, chemical and rheological Properties.
- Improve the pavements and mix design.
- Improve the construction methods and maintenance techniques.

Modified asphalt is assumed to be one of the most important solutions for pavement distress. To produce modified asphalt there are several methods and different materials at different modification level. To reduce the cost of highway construction and maintenance, asphalt researchers look for alternative additives materials such as silica fumes, fly ash, and lime. The effect of different types of modifiers to improve fatigue resistance of asphalt pavement is a field of interest for many asphalt researchers, but efforts concentrated on the fatigue resistance for asphalt concrete mixtures are scarce. Silica fume is a good alternative of the most new important commercial materials that are used to improve the properties of asphalt mixtures and asphalt, **Sarsam and AL-Lamy, 2015.** Silica fume is one of the materials which is easy to use and mix with asphalt materials for being too fine; have positive effect on asphalt cement by reducing its temperature susceptibility, silica fumes exhibit lower, reduction in the stiffness modulus., **Sarsam, 2008 and AL-Zubaidi, 2014.**

2. MATERIALS CHARACTERISTICS

2.1 Asphalt Cement

Asphalt cement was obtained from Nasiriya oil refinery; the physical properties are listed in

Table 1.

2.2 Aggregate

Crushed coarse aggregate (retained on sieve No.4) was obtained from AL-Ukhaydir- at Karbala quarry. Crushed sand and natural sand used as Fine aggregate (particle size distribution between sieve No.4 and sieve No.200), was brought from the same source. It consists of hard, tough grains, free from loam and other deleterious substances. The physical properties are listed in **Table 2.**

2.3 Mineral Filler

The mineral filler is a non-plastic material, mostly passing sieve No.200 (0.075mm). The filler used in this work is limestone dust obtained from factory in Holly Karbala governorate. The phy**sical** properties of the used filler are presented in **Table 3.**

2.4 Silica Fumes

It was manufactured by Wacker Silicon Company in Germany as fluffy powder, and obtained from local market, **Table 4** Shows its physical properties. **Plate 1** Shows the sample of Silica fumes used. It was decided to use silica fumes based on previous work, **Sarsam, 2008.**

3. TESTING PROGRAM

3.1 Preparation of Modified Asphalt Cement

Modified asphalt was prepared by using the wet process. In the wet process, asphalt cement has been heated to a 150 °C and then blended with a Silica Fume modifier with different content (1%, 2 % and 3%by weight of asphalt cement). Such percentages were based on **Sarsam, 2013** work, it was prepared in the laboratory using special manufactured mixer at a blending speed of about 1300 rpm and elevated temperatures (177-190°C) for 20 minutes to promote the chemical and physical bonding of the components. During the blending process, the asphalt cement swells and softens as an indication of possible reacts with Silica fumes**. Plate 2** Shows the blending apparatus.

3.2 Preparation of (Flexural Fatigue Beam Test) Specimens

The dimensions of the beam specimen used were 50±6 mm high, 63±6 mm wide and 400 mm (15.75 in) long according to AASHTO T 321, (2007). The bulk density was 2.2826 Kg/m^3 for every specimen as presented in AASHTO T166, (2010). The aggregate and asphalt were mixed in mixing bowel on hot plate for three minutes until asphalt sufficiently coated the surface of the aggregates. The asphalt-aggregate mixture was then subjected to short term oven aged for 4hrs at temperature of 135 C according to AASHTO PP2. The mix was stirred every 30 minutes during the short term aging process to prevent the outside of the mixture from aging more than the inner side because of increased air exposure, then the asphalt concrete mix was casted slab mold. Tests were conducted at optimum asphalt content and at asphalt contents of 0.5 percent above, and 0.5 percent below optimum. Specimens for flexural fatigue testing were prepared using Roller Compactor Device at NCCLR according to, **EN12697-33 ,2003**, because this method of compaction simulates field compaction in a progressive way. A slabs specimen of (400 mm by 300 mm by 50±6 mm) was prepared using the hot aged asphalt concrete loose mix. The dimensions of the compacted slabs used are 400 mm (15.75 inch) in length and 300 mm (11.8 inch) in width and 60 mm (2.36 inch) in height. with astatic load was (5 kN) and number of variable passes depended on the asphalt content in mix (where 20 number use of passes for 5.4% asphalt content, 30 number of passes for 4.9% asphalt content(optimum),and 60passes for 4.4%asphalt content, by trial and error).12 slab samples were prepared, then cut by the Diamond-cutter into dimension previously mentioned, **Plates 3, 4 and 5** give an illustration of compacted and cut samples of slab and beam. The total number in all test was (24 beams).control mixture (9 beams), and Modified mixture by using silica fume (15 beams). A total of 36 beam specimens were tested for fatigue behavior.

4. DISCUSSION OF TEST RESULTS

4.1 The Effect of Silica Fumes Content on Fatigue Life

Fig.1 depicts the effect of Silica fumes content on fatigue life. From the analysis of the results, it can be seen that when Silica fumes content was 1% that fatigue life increases by 17%, and it increases by 46%when Fly ash content increases to 2%, and that fatigue life increases to 34 % when Silica fumes content increases to 3% as compared with control mixture (250 µƐ, 20°C and optimum asphalt content). Because the mixture became more flexibility .it may be related to increasing viscosity and stiffness of mixture**.**

Based on the data shown in **Table 5**. It appears that the fatigue life increases by 20%, 115%, and 80% at Silica fumes content 1%, 2%, and 3% respectively, as compared with control mixture (400 µƐ, 20°C and optimum asphalt content), and that the fatigue life increases by 7%, 57%, and 33% at Silica fumes content 1%, 2%, and 3% respectively as compared with control mixture (750 µƐ, 20°C and optimum asphalt content).

Generally, increases in micro strain level lead to reduces in the fatigue life value in the same mixture. For example at modified mix by using 2% Silica fume it can be noted that fatigue life reduced by 75% when micro strain level change from 250 µƐ to 400 µƐ, decreases to 84% when micro strain level increases from 400µƐ to 750µ.

Also we noted that the Silica fume has a significant effect on the fatigue life. The analysis of the data shown in **Table 5.** Depicts when Silica fume content change from 1% to 2% that fatigue life increases by 24% but when Silica fumes content change from 2% to 3% that fatigue life reduced by 8%. Finally, from the results above, it can be concluded that optimum Silica fumes content was 2% from fatigue life point of view.

4.1.2 The effect of asphalt content on fatigue life

The effect of asphalt content on modified and unmodified mixture was depicted in **Fig.2**. K1 and K2 parameters can be concluded from the data shown in **Fig. 2 and Table 6**. Failure criteria implemented was that when the reduction in beam stiffness will reach 50% of its initial stiffness, the number of loading cycles is considered as fatigue life.

It can be seen that fatigue life increases significantly, because increasing thickness of asphalt film between aggregate leads to decreases tensile strain at the bottom of layer, **Alwan, 2012 and Al-kashaab, (2009)**

The analysis of this figure shows when asphalt content decreasing from 4.9 to 4.4 percent the fatigue life decreases 55% at control mix, it decreases 53% at modified mixture by using Silica fume, (at 250 µƐ). While when asphalt content increases from 4.9 to 5.4 percent the fatigue life increases 53% at control mix, 60% at Silica fume.

Fig. 3 shows the impact of silica fumes on fatigue life of asphalt concrete, when micro strain level increases the fatigue life decreases significantly. So fatigue life reduces 30% at control mix, 64% at S.F, when asphalt content increases from 4.9 to 4.4. When micro strain level change from 250 µƐ to 400 µƐ, and increases by (16%, 8%) at Control mix, S.F, respectively, when asphalt content increases from 4.9 to 5.4 percent.

Also when micro strain level change from 400 to 750. Fatigue life reduces 13% at control mix, 22% at S.F, when asphalt content increases from 4.9 to 4.4 percent, and increases by (19%, 6%) at Control mix, S.F, respectively, when asphalt content increases from 4.9 to 5.4 percent. **Table 6** depicts the effect of asphalt content on modified and unmodified mixture in relation to the fatigue life cycle at different micro strain level. It depicts that when using Silica fumes, fatigue life increases 50%, as compared with conventional mix (at 250 µƐ, at 4.4% asphalt content), the fatigue life increases by 9% when using Silica fume as compared with control mix (at 400 μƐ, at 4.4% asphalt content).also it increases by 25 using Silica fume (at 750 μƐ, at 4.4% asphalt content). It shows that the difference in the ratios of the fatigue life at optimum asphalt content 4.9%. The analysis of the figure shows the percentage of change varying significantly, it can be seen the fatigue life increases 46% when using Silica Fumes (at 250 μƐ), it increases by 115% (at 400 μƐ), at 750 μƐ the fatigue life increases by 40% (All of these ratios were compared with control mix).

Table 6 shows comparative between modified and unmodified mixture toward the fatigue life at (optimum asphalt content +0.5%, 5.4%). It can be seen the fatigue life increases 53% at Silica Fumes (at 250 μƐ), it increases by 100% at S.F (at 400 μƐ), at 750 μƐ the fatigue life increases by 33% at Silica Fumes (All of these ratios were compared with control mix). K1 and K2 can be concluded from the data shown in **Tables 7**. It was noted at 4.4% AC that K2 increases nearly by 6.9% and increases by 1.3% at 4.9%AC, and increases by 1.5% at 5.4% AC (at modified mixture by using Silica fumes respectively), as compared with control mix. K1 has the smallest values and decreases it was decreases slightly when using additives.

5. CONCLUSIONS

1-Accorcing to the results obtained from “Flexural Fatigue beam Test”, it turns out that the perfect percentage of Silica fumes addition is (2%).

2- Decrease in Asphalt percentage by (0.5%) from the optimum asphalt content would result in a decrease in fatigue life by (55%) for control mixture and (45%) for the mixture modified by using Silica fumes. On the other hand, the effect of the additives was obvious in increasing the fatigue life by (50%) for Silica fume, as compared to the control mixture (at 250με, 20°C, 4.4%AC).

3-Increase in Asphalt percentage by (0.5%) from the optimum asphalt content would increase the value of fatigue life by (53%) for the control mixture and by (48%) percent for the Silica fumes. Also the additives have Effect in an increase of the fatigue life value, as compared to control mixture by (41%) for the Silica.

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Table 1. Physical properties of asphalt cement.

Property	Unite	Test result	SCRB Specifications
Penetration 25˚c , 100gm5 sec(ASTM D-5)	0.1 mm	42	40-50
Softening point, Ring and ball (ASTM D-36)	°C	49	………….
Ductility, 25°C, 5 cm/min (ASTM D-113)	cm	136	>100
After thin film oven test (ASTM D-1754)			
penetration, 25°C, 100gm, 5 se	%	73	>55%
Ductility, 25°C, 5 cm/min	%	83	>25%

Table 2. Physical properties of coarse and fine aggregate.

Property	value	ASTM Designation No.
Coarse Aggregate		
Bulk specific gravity	2.542	C127-01
Water absorption %	1.076%	C127-01
Wear %(los Angeles abrasion)	18%	C131-03
Fine Aggregate		
Bulk specific gravity	2.558	C128-01
Apparent specific gravity	2.563	C128-01
Water absorption %	1.83%	C128-01

Table 3. Physical properties of filler (Lime stone).

Property	Value
Bulk specific gravity	2.617
% Passing Sieve No.200	94

Table 4. Physical properties of silica fumes.

Maximum sieve size	PH value	Density (kg/m^3)	Specific surface area (m^2/ kg)
Passing 0.075	4.5	2.6455	200000

Table 5. Effect of additives type and content on fatigue life.

Mix. Type	Additives%	Micro strain level		
		250 µƐ	400 µƐ	750 µƐ
Control mix	0%	16212	2722	563
Modified mixture	1% S.F	19065	3280	604
	2% S.F	23671	5857	889
	3% S.F	21740	4881	751

Table 6. Fatigue life for control and modified mixture.

AC%	State	Fatigue Life, Nf		
		250 µƐ	400 µƐ	750 µƐ
4.4 %	Control mix	7421	1897	486
	S.F	10931	2070	609
4.9 %	Control mix	16212	2722	563
	S.F	23671	5857	789
5.4%	Control mix	24879	3182	670
	S.F	35084	6381	892

Table 7. Fatigue parameters K1, K2 and equations for fatigue life under effect of asphalt content

AC%	State	K1	K2	Equations
4.4 %	Control mix	1.07E-05	2.450	Nf=1.07E-05$(Ɛ)^{-2.450}$
	S.A	3.96E-06	2.620	Nf=3.96E-06$(Ɛ)^{-2.620}$
4.9 %	Control mix	1.65E-07	3.050	Nf=1.65E-07$(Ɛ)^{-3.050}$
	S.F	1.74E-07	3.090	Nf=1.74E-07$(Ɛ)^{-3.090}$
5.4%	Control mix	3.57E-08	3.290	Nf=3.57E-08$(Ɛ)^{-3.290}$
	S.F	3.25E-08	3.340	Nf=3.25E-08$(Ɛ)^{-3.340}$

Plate 1. Silica fume sample.

Plate 2. Manufactured blending apparatus and its components.

Plate 3. Slab specimens.

Plate 4. preparation for obtaining beams.

Plate 5. Four points bending beam device and testing equipment at NCCLR.

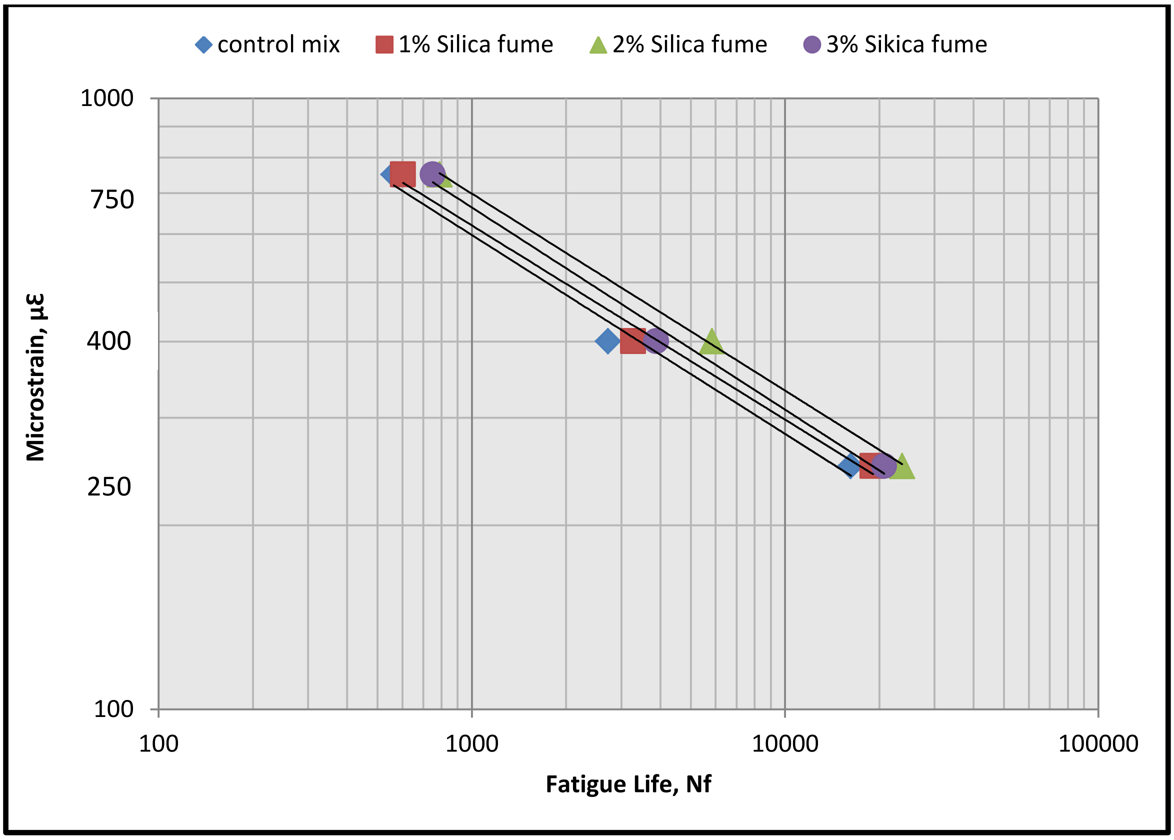

Figure1. Effect of different percent of silica fume on fatigue life to select the best percent, T=20°C

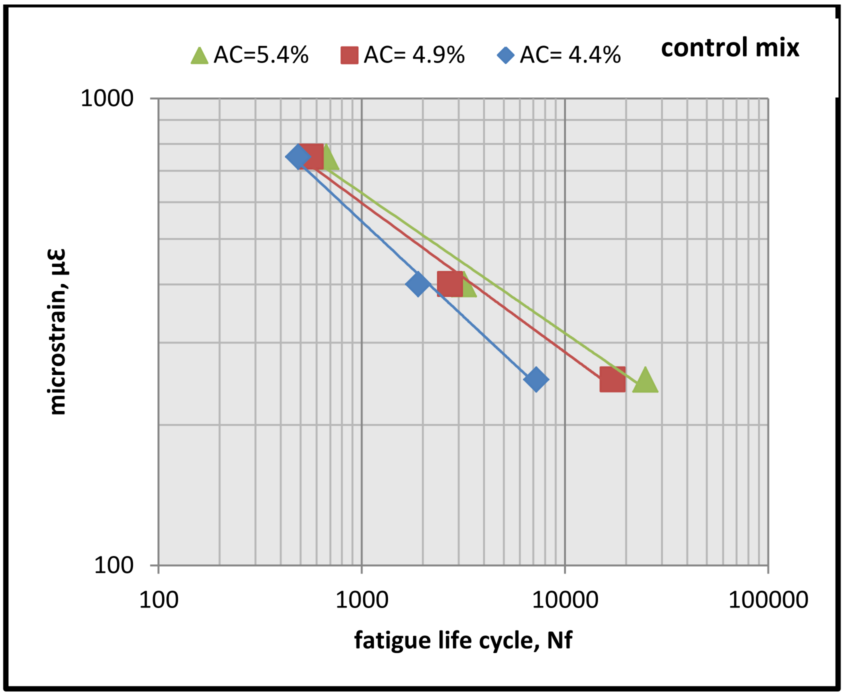

Figure 2. Effect of asphalt content on fatigue life for control mix, T=20°C.

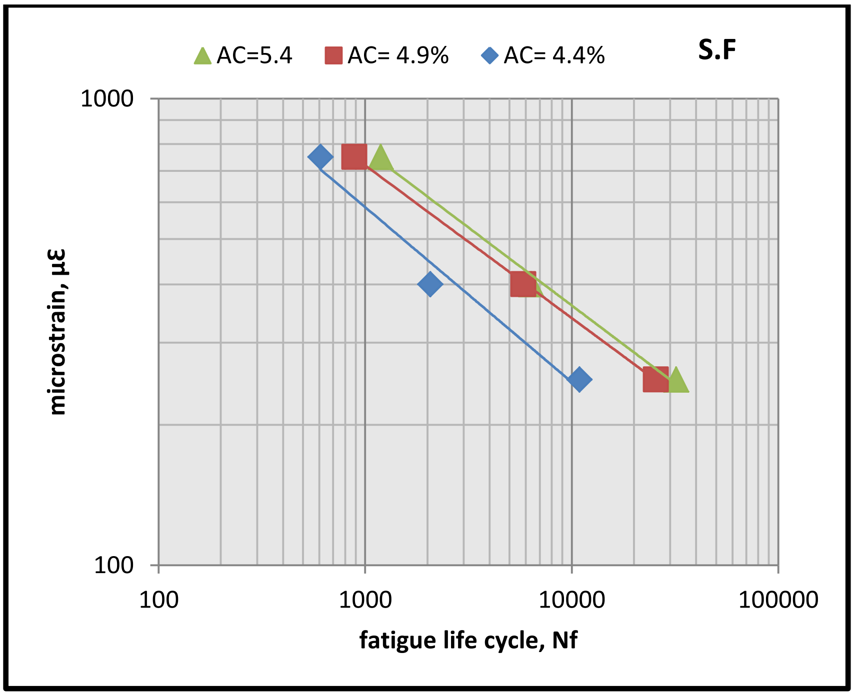

Figure 3. Effect of asphalt content on fatigue life for modified mix, T=20°C.

Effect of Transverse Internal Ribs on Shear Strength Evaluation of Hollow RC Beams

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ABSTRACT

This paper is devoted to investigate experimentally and theoretically the structural behavior of reinforced concrete hollow beams which have internal transverse ribs under effect of shear. The number of the internal ribs is the major variable adopted in this research, while, the other variables are kept constant for all tested specimens. The experimental part includes poured and test of four (200x300x1200mm) beam specimens, three of these specimens were hollow with different locations of internal ribs and one of them was solid. The experimental results indicated that the shear strength are increased (33%) to (60%) for beams containing internal ribs in comparison with reference beam. Also, the change of beam state from hollow section to solid section led to increase the capacity for about (100%). In order to study more thoroughly the performance of tested beams, a nonlinear analysis using ANSYS-11 finite element program is used. The analytical results indicated that the load-deflection response, ultimate loads, and crack pattern are in good agreement with the experimental results.

Key words: shear, hollow beam, reinforced concrete, internal ribs, ansys.

تاثير الاضلاع المستعرضه الداخليه على تقييم مقاومة القص للعتبات الخرسانيه المسلحه المجوفه

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الخلاصه

يختص هذا البحث في التحري العملي و النظري للسلوك الانشائي للعتبات الخرسانية المجوفة التي تحتوي على اضلاع بالاتجاة العرضي تحت تأثير القص. ان المتغير الرئيسي المعتمد في هذا البحث هو عدد الاضلاع الداخليه، بينما تم الابقاء على المتغيرات الاخرى ثابتة لكل العتبات المفحوصه. تضمن الجزء المختبري صب وفحص أربعة عتبات خرسانيه مسلحه بابعاد (200x300x1200 ملم) ثلاثة منها بمقاطع مجوفه تحتوي على اضلاع مستعرضه بمواقع مختلفة والاخير بمقطع صلد. اشارت النتائج المختبريه الى أن مقاومه القص ازدادت بمقدار (33%) الى (60%) للعتبات المجوفه الحاويه على اضلاع مستعرضه مقارنة مع العتبه المرجعيه. ان تغيير حالة او نوع العتبه من المجوفه الى الصلده ادى إلى زيادة التحمل الاقصى بحدود (100%). لغرض دراسة النماذج المفحوصه بشموليه أكثر، استخدم التحليل اللا خطي باستخدام برنامج العناصر المحدده (ANSYS) الإصدار-11-. اشارت النتائج التحليلية أن استجابة الانحراف-الحمل ، الحمل الاقصى، و شكل الشق في توافق جيد مع النتائج المختبريه.

الكلمات الرئيسيه: القص، عتبة مجوفه، الخرسانه المسلحه، الاضلاع الداخليه، البرنامج ansys

1. INTRODUCTION

Hollow (or box) cross section beam, mean closed thin walled section beam. A thin walled beam is characterized by relative magnitude of its dimensions; the wall thickness is small compared to the other linear dimensions of the cross section, **Abbas, 2007**. A hollow beam structure consists of top and bottom flanges connected by vertical (or inclined) webs to form a cellular section. Presence of these hollow through a solid beam eliminates a significant amount of dead space, and as a result the beam stiffness reduced and this lead to alter the simple beam behavior to a more complex one. The reduced stiffness of the beam may also give rise to excessive deflection under service load and result in a considerable redistribution of internal forces and moments. These sections are used for the various fields such that in buildings, hall, bridges, offshore structure and towers, **AL-Maliki, 2013**. It is one of the most popular forms of highway bridges; primarily because of the high flexural and torsion rigidities .The use of box beams in highway-bridge construction has proven to be a very efficient structural solution, **Al-Janabi, 2005**.

Several researches are interest in hollow beams under the effect of flexural, shear and torsion loads, **Chiad, 2013**. Shear behavior of reinforced self-compacting concrete deep box beams strengthened internally by transverse ribs, also studied, **Ruaa, 2015**. In the present research, shear behavior of reinforced concrete hollow beam strengthened internally by transverse ribs will be studied as well as the effect of the number of internal cells which were separated from each other by concrete ribs.

2. EXPERIMENTAL WORK

2.1. Experimental Program

In this paper, four simply supported beam specimens with rectangular sectional area, under monotonically concentrated load were poured and tested. The tested beams are reinforced in longitudinal direction (flexural reinforcement at the bottom), transverse direction (shear reinforcement) and have been designed to ensure failed in shear mode of failure. The number of internal cells, which were separated from each other by concrete ribs, is the major adopted variable. The sectional area, length, ratio of shear span-to-depth, flexural and shear reinforcement are kept without change for all tested beams. To evaluate the compressive strength of concrete, the experimental program consists, also, cast and test of a series of control specimens (cubes).

2.2. Beam Sample Details

The actual dimensions and the details of beam specimen are shown in **Fig**.1 and **Table** 1. The overall length is (1200 mm), while, the overall depth and width are (300mm) and (200 mm) respectively. All beam specimens are reinforced with ($2\phi 12$ mm) deformed bars as tension (flexural) at the bottom and ($\phi 6$ mm @150mm) deformed bars as shear reinforcement (stirrups). To hold the shear reinforcement (stirrups) in place, ($2\phi 4$ mm) smooth bars at the top are used, see **Fig**. 2.

The first beam specimen, (B-1), is poured without any internal ribs (but with two ribs at the ends), while the beam specimens (B-2) and (B-3), are poured with one and three internal ribs (in addition to two ribs at the ends) respectively. The last beam specimen, (B4), is poured without internal cells (solid). For beam specimens containing ribs (interior or at the ends), the thickness of rib is (50mm). It may be noted that the main function of the ribs at the ends is to prevent the local failure of hollow beams due to high concentration of stress near supports. While, the main function of the internal ribs is to assist or evaluate its contribution to increase shear strength of tested beams (that have internal ribs). The locations of ribs are shown in **Figs**. 3 and 4.

The cross section of the hollow beam contains a polystyrene void that blocks out the center of the beam over specified lengths. The void is included to block out concrete where it does not add much resistance to the section and reduce the self-weight of the beam. For practical reasons, the void in the beam cross-section is obtained by a stay-in-place polystyrene block. The creation of the void through the polystyrene block makes casting the beam both time and labor intensive. There are three lengths of polystyrene block pieces as shown in **Fig**. 4.

1- One piece with length of (1100mm), for beam specimen (B-1), with one cell and one rib (50mm width), at each end of the beam.
2- Two pieces with length of (525mm) for each one of them for beam specimen (B-2), with two cells separated by three ribs (50mm width) (one internal and two at the ends).
3- Four pieces with length of (237.5mm) for each one of them for beam specimens (B-3), with four cells separated by five ribs (50mm width) (three internal and two at the ends).

2.3. Materials

In manufacturing the tested specimens, local construction materials are used (except steel bars), description of materials properties are reported and presented in **Table** 2.

Tensile test of steel reinforcement (manufactured in Ukraine) is carried out on (ϕ12mm) hot rolled, deformed, high tensile steel bar used as flexural reinforcement, and (ϕ6mm) deformed mild steel bar was used as stirrups (shear reinforcement). Also, the test included testing of (ϕ4mm) plain mild steel bar which was used to hold stirrups in place. **Table** 3 shows the results of tensile test for bars.

2.4. Concrete Mix Design

One concrete mix is used in this work; the concrete mix proportions are reported in **Table** 4. It was found that the used mix produces good workability and uniform mixing of concrete without segregation.

2.5. Molds

One wooden molds containing four boxes, (200x300x1200mm) dimensions are used to poured beam specimens. The molds were manufactured with (18mm) thick plywood base and seven movable sides. The sides were fixed to the base by screws. When the mixing process was completed, the samples were then cast in layers and compacted by a table vibrator to shake the concrete and consolidate it into the molds. Then, the top face of samples (top surface) was finished and leveled off by using steel trowel; and finally the samples were covered by a nylon sheets to impede water evaporation. It may be noted that, to ensure that it would be easy to remove the samples when the concrete hardened, the inner faces of molds was oiled.

2.6. Test Apparatus

Hydraulic machine was used to test the control specimens and beam specimens. Deflection at the mid-span (center) has been measured by using ELE type dial gauge of (30mm) capacity and (0.01mm) accuracy. The ELE gauge was put below the bottom face of each span at the mid. Beam profile and loading arrangement is shown in **Fig**. 5.

2.7. Concrete Mixing and Placing (Pouring)

2.7.1. **Concrete mixer and vibrating table**

The concrete was mixed by using a horizontal rotary mixer with (0.19 m^3) capacity. While, vibrating table are used to vibrate the concrete of specimens (beams and control specimens). The vibrating table consists of (1.0x1.5m) table made of (10mm) thick steel plate. The source of vibration was a rapidly rotating eccentric weight which makes the table vibrates with a simple harmonic motion. The vibrator was manufactured by Marui Company, Japan. The frequency of vibration was (7000rpm).

2.7.2. **Curing and age of testing**

After (24) hours, the beam specimens and control specimens were stripped from the molds and cured in water bath for (28) days with almost constant laboratory temperature. Before (24) hours from the date of testing, they were taken out of the water bath and tested in accordance with the standard specifications.

2.8. Results of Control Specimens Tests

Mechanical properties tested results of control specimens (compressive strength) are reported and summarized in **Table** 5. Cubes compressive strength (f_{cu}) was carried out on concrete based on BSI **881-116** with standard cubes (150mm). The cubes were loaded uniaxially by the universal compressive machine up to failure.

2.9. Test Methodology (Test Procedure)

The beams were tested at (28 days) age, where they were prepared by cleaning them and paint with white color, in order to detect the propagation of cracks. The beam specimens have been placed on the testing machine with a clear span of (1100mm), then adjusted to fit the supports, beam centerline, dial gauge and finally tested under a monotonic single-point loading up to failure; **Fig**. 5 shows the setup of beam specimens.

Initially each beam is loaded with small load to ensure that the dial a gauge is in touch with the bottom faces of beams and working correctly. After that, the load increased regularly at (1.0 kN/sec) and the readings taken every (5 kN). When the beams reached advanced stage of loading, smaller increments of load were applied until failure, as the load indicator stopped in recording or returned back and the deflection increased very fast without any increase in applied load. Throughout the test, all necessary measurements and notices were recorded.

3. THEORETICAL STUDY

To study the performance of tested beams, ANSYS (Version-11) finite element program is used to analyze two selected beam specimens, (B-1) and (B-2). A nonlinear, eight nodes brick element, (SOLID-65), with three translations DOF at each node is used to model the concrete. For FEM modeling of the steel reinforcement, two nodes, discrete axial element, (LINK-8), with three translations DOF at each node is used. To avoid stress concentration, (10mm) thick steel plate is added at the load locations and modeled by using a nonlinear, eight nodes brick element, (SOLID-45), with three translations DOF (per node) in x, y and z-directions.

3.1. Properties of Materials

3.1.1. Concretes

For finite element modeling, concrete constitutive stress-strain curve in compression can be described by isotropically, multi-linear stress-strain relationship. Constitutive model (surface of failure) in ansys can be specifying only by two constants (tensile strength (f_t) and compressive strength of concrete ($f_c^{'}$)) as given by criterion of **Willam** and **Warnke, 1975**.

In this paper, transfer coefficients of shear for opened cracks (β_o) and closed cracks (β_c) are assumed to be (0.2) and (0.25) respectively. These values are selected to avoid convergence problems during iteration.

The stress-strain curve for concrete in tension is assumed to be linear-elastic up to the maximum tensile strength. Smeared crack approach is used to model the concrete cracking. Poisson's ratio, for finite element modeling of concrete is assumed to be (0.2). In order to modeling the finite element of concrete, empirical equations of ACI-318 Committee are used to determine the young's modulus and tensile strength, as listed in **Table** 6.

3.1.2. Steel Plates and Reinforcement

Elastic modulus and yield stress for the steel plates and reinforcement used in FEM follow the design material properties used for the experimental investigation. The steel for the finite element models is assumed to be an elastic-perfectly plastic with strain hardening material and identical in tension and compression as shown in **Fig**. 6. Von-Mises failure criterion is adopted for modeling. To avoid convergence problems during program iteration, the modulus of strain hardening is assumed to be (0.03x E_s).

The steel plate under the applied load is assumed to be behaves as linearly-elastic materials. Young's modulus of (200GPa) and Poisson's ratio of (0.3) are utilized in FEM for steel plates and reinforcement.

3.2. Finite Element Modeling

The dimensions of the beam specimens are shown in Fig. 1. Due to variation of internal ribs locations and simple geometry of the tested beams, entire (full) beam is used for modeling, **Fig**. 7.

It may be noted that, the origin point of coordinates lie in one corners and only one loading plate are provided at the top of beam (under load) to prevent load concentration. In the beginning, the beams and steel plates are modeled as lines, then areas, and finally as volumes (solid elements).

3.2.1. **Finite element meshing**

After creating of volumes, meshing of the finite element model is needed. In this stage, the FEM model is divided into a number of small elements. When the model problem is solving, the stresses and deformations (strains) are estimated at the Gaussian points of these small elements. Best results can be achieved by dived (meshing) the model into square (or rectangular) elements, **Fig**. 7.

Before distribution (spreading) of the applied load by using steel plates (in the early attempt), and due to load concentration on concrete elements, concrete crushing started to create in elements which located directly under load. Thereafter, the concrete elements adjacent to the applied load were crushed within few steps of loading. Finally, large displacement (deflection) take place, the solution in not converges and as a result the FEM model failed prematurely. To prevent this FEM failure phenomenon, steel plates are used and inserted under the applied load.

3.2.2. **Load application and boundary conditions**

To ensure that modeled beams behave as tested beams, boundary conditions (displacement constrains) at supports should be satisfied (need to be applied at the supports locations). Thereafter, one of the supports is to be modeled as a hinge and the other one is modeled as a roller.

Since the external load was applied on a steed plate and as a basic of FEM, the plate load must be transformed to adjacent nodes; therefore the applied load is represented by an equivalent nodal force on the top nodes of plate. Since the steel plate had eight divisions in transverse direction (Z-direction), the equivalent nodal force on the plate becomes (P/9) of the applied force (assuming equally distributed of applied load).

The applied load is divided into load steps and done incrementally up to failure (based on Newton-Raphson technique). At a certain stages in the analysis, load step size is varied from large (at points of linearity in the response) to small (when cracking and steel yielding occurred). The failure is assumed to be occurred when the solution, for a minimum load is diverging and the models have a large deflection (rigid body motion).

4. RESULTS AND DISCUSSIONS

As indicated before, the aims of this paper are to evaluate the effect and contribution of internal ribs (at different locations) on shear strength of hollow reinforced concrete beams.

4.1. Experimental Results

Ultimate load capacities, load versus deflection at the center of the bottom face of each tested beam were recorded throughout the experimental work. To appear the cracks pattern and imported details, photographs for the tested specimens are taken. Tests observations, general behavior and recorded data are reported to recognize and understand the effects of adopted parameters on the strength of the tested specimens.

4.1.1. **General behavior**

Photographs of the tested beams are shown in **Fig. 8** and tests results are given in **Table 7.** It may be noted that, all beam specimens were designed to be failed in shear, which was distinguished by sudden failure and diagonally wide cracks which extend from supports towards the applied load locations.

The general behavior of the tested beams can be described as follows; at early stages of loading, small vertical deflection initiated in the mid span of tested beams, with further loading, diagonal cracks extended upwards and became wider in shear span. One or more cracks propagated faster than the others and extend through weak locations in the beam (hollow zones) and reached the compression face (near applied load), where crushing of the concrete near the positions of applied loads had occurred due to high concentrated stresses under load.

4.1.2. **Failure mode**

The appearance of the cracks reflects the failure mode for the tested beams. The experimental evidences show that the diagonal cracks extended horizontally along the tension reinforcement and eventually, the failure take place due to diagonal tension cracks were formed diagonally and moved up and towards the position of load, this crack is associated with crushing of the concrete near the positions of applied loads, this mode of failure is called “Shear-Compression” failure, as shown in **Fig**. 8.

4.1.3. **Ultimate shear strength (Vu)**

The recorded ultimate loads of the tested beams are presented in **Table 7**. As expected, test results show that the reference beam (B-1) has the minimum ultimate strength in comparison with the rest beams. This may be due to absent of any internal ribs (concrete) in the section (in shear span).

As shown in **Table** 7, the ultimate shear strength increased when the number of ribs increased (in shear span) and when we moved toward of and closes up to the support.

For the tested beam (B-4), which have made as solid without hollows, the ultimate shear strength increased by (100%) in comparison with reference beam, this clearly due to concrete contribution to resist shear stress.

The ultimate shear strength increased about (33%) to (60%) for the tested beams (B-2) and (B-3) respectively, the presence of internal ribs led to increase resistant area of concrete and as a results, the shear strength increased significantly.

4.1.4. Effect of number of ribs on ultimate strength

As shown in Table (7), presence of internal ribs in hollow section leads to increases the stiffness of tested beams due to concrete contribution, and this leads to increase in carrying capacity.

In other words, due to abrupt changes in the sectional configuration (from solid to hollow), the hollow beam corners, closed thin webs and flanges are subject to high stress concentration that may lead to reduction in stiffness of the tested beam and produced cracking and excessive deflection, see **Fig**. 9.

As shown in **Table** 7, presence of internal ribs (see B-2 and B-3), led to increase the ultimate shear strength from (33%) to (60%). The increasing in ultimate load was (100%) for tested beam (B-4) when the section made fully without hollows. This means that the presence of internal ribs affected significantly on ultimate capacity of tested beams.

4.1.5. Load versus deflection curves

Load versus deflection curves of the tested beam specimens at the center of bottom face at all loading increments up to failure are shown in **Fig**. 9.

In the beginning, the curves are identical and the tested beams exhibited linear behavior and the initial change of slope of the load-deflection curves occurred between (10 kN to 30kN), which may be indicated the first crack loads. Beyond the first crack loading, each beam behaved in a certain manner. Behavior of reference Beam (B-4) exhibited greater loads and smaller deflections in comparison with the other beams. This beam had the greatest stiffness due to absent of any hollows.

Load-deflection curves for the tested beams (B-1, B-2 and B-3) shows smooth increase, in both, applied loads and deflection. Presences of hollows lead to decreasing in carrying capacity of load beyond the first cracking, this associated with reduction in beams stiffness and this is reflected on the associated deflection (excessive deflection). For tested beams (B-1 and B-2), slight increase in ultimate deflection of beam (B-1) is observed by comparing with (B-2). This is may be due to absent of any interior rib in the beam (B-1) which leads to decreasing of beam rigidity (stiffness) and as a result, slight increases in deflection is occurred.

4.2. Finite Element Results

4.2.1. Load versus deflection curves

Vertical displacements (Deflection in y-direction) are measured, at mid-span, at the center of the bottom face of tested beams. Deflected shape of finite element beam model due to the vertical load is shown in **Fig**. 10. The load versus deflection curves obtained from the FEM analysis together with the experimental tests are constructed and compared in **Fig**. 11, for tested beams (B-1) and (B-2). In general, it can be noted from the load-deflection curves that the finite element analyses are agree well with the experimental results throughout the entire range of behavior. Comparing with the experimental results, all the finite element models show relatively large capacity at the ultimate stage.

4.2.2. Ultimate loads

Table 8 shows the comparison between the ultimate loads of the experimental (tested) beams, $(P_u)_{EXP}$., and the final loads from the finite element models, $(P_u)_{FEM}$. The final loads for the finite element models are the last applied load steps before the solution starts to diverge due to numerous cracks and large deflections.
As shown in **Table** 8, the ultimate loads obtained from numerical model agree well with the corresponding values of the experimental (tested) beams.

4.2.3. Crack patterns

The crack pattern is recorded, after first crack, at each load step. Cracks pattern come by the FEM analysis and the failure modes of the tested beams are agree well, as shown in **Fig**. 12.

Cracks pattern appearances reflect the failure mode of tested specimens. The model of FEM, accurately, predicts that the tested beams are failing in shear and predicts that the vertical and inclined cracks formed in the shear span regions respectively. The cracks are concentrated under load region and vanish diagonally towards the beam supports.

5. CONCLUSIONS

In the previous items, an experimental program together with finite element analysis has been performed, thereafter the following conclusions are obtained:-
1-Ultimate load carrying capacity in beams is found to be increasing with increase the number of the internal ribs, and the deflection at ultimate load is found to be decreasing.
2-The ribs work as internal stiffeners which contributed to increase the shear strength in a certain degree. The shear strength increased (33%) and (60%) for beams containing one and three internal ribs respectively.
3-The change of beam state from hollow section to solid section led to increase the capacity for about (100%).
4-Based FEM analysis (using ANSYS program), it can be concluded that the computational finite element models adopted in the current study are useful and able to simulate the behavior of tested beams. The analytical tests indicated that the load-deflection responses, ultimate loads and the structural behavior are in good agreement with the experimental results.

6. NOMENCLATURE

b_w = beam width, m.
h = overall depth of beam, m.
d = effective depth, m.
f'_c = cylinder compressive strength of concrete, MPa.
f_{cu}= cube compressive strength of concrete, MPa.
f_t = tensile strength of concrete, MPa.
f_y = yield strength of steel bars, MPa.

f_u= ultimate tensile strength of steel bars, MPa.
E_c= modulus of elasticity of concrete, MPa.
E_s= modulus of elasticity of steel, MPa.
P_c = cracking load, kN.
P_u = ultimate load, kN.
V_u= ultimate Shear Force, kN.
$(V_u)_i$= ultimate Shear Force of a certain beam, kN.
ϕ = reinforced bar diameter,mm.
β_c shear transfer coefficient for closed cracks.
β_o shear transfer coefficient for open cracks.

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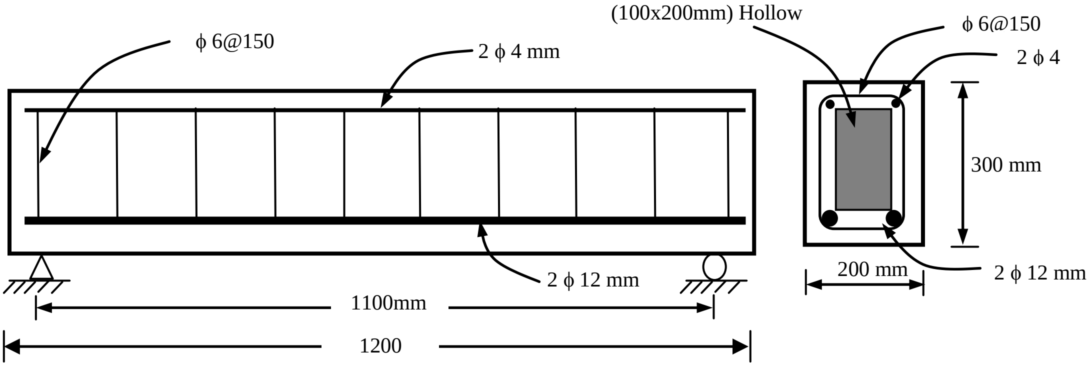

Figure 1. Details of tested beams.

Figure 2. Details of reinforcement.

Figure 3. Details of polystyrene blocks (inside mold).

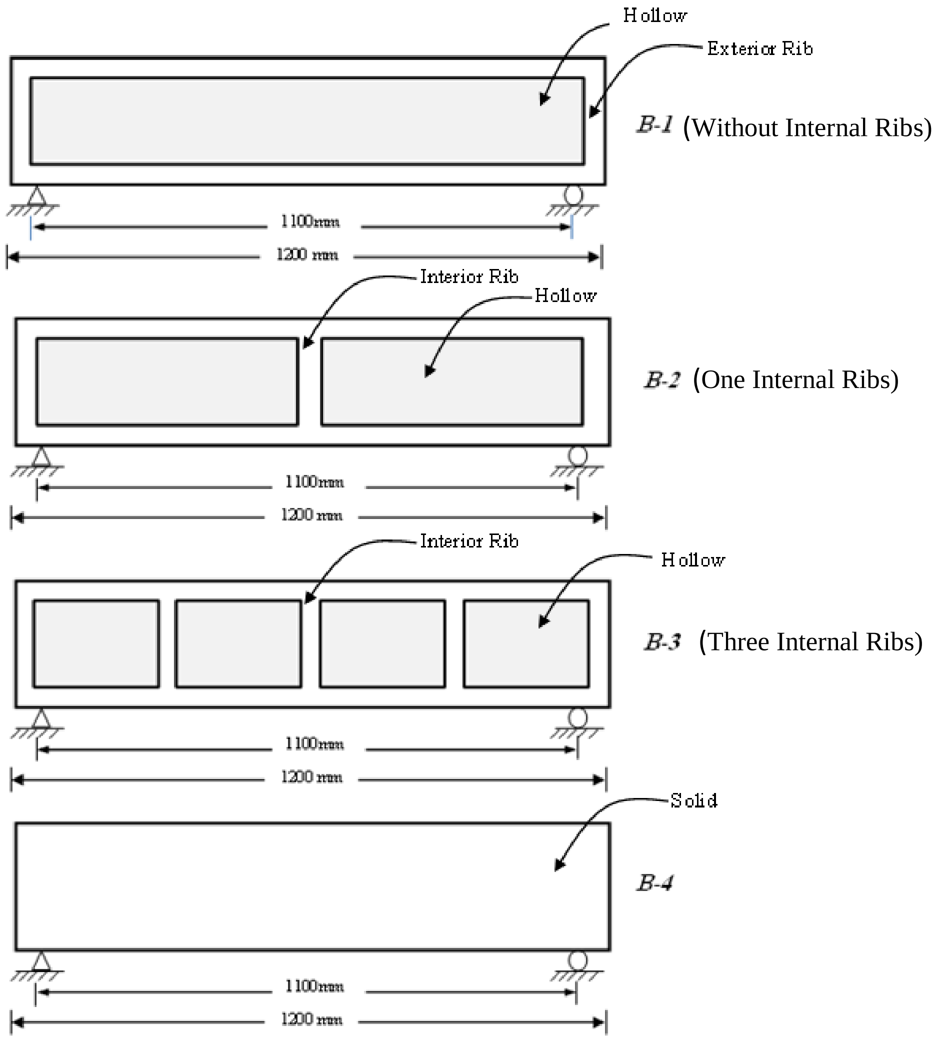

Figure 4. Locations of external and internal ribs (longitudinal section).

Figure 5. Beam specimen setup.

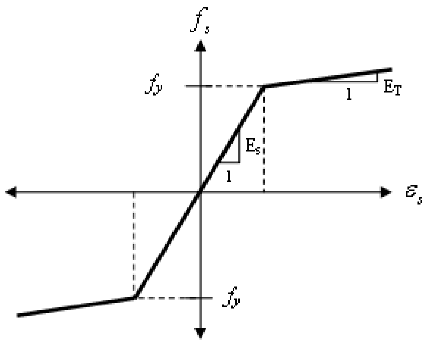

Figure 6. Modeling of steel materials.

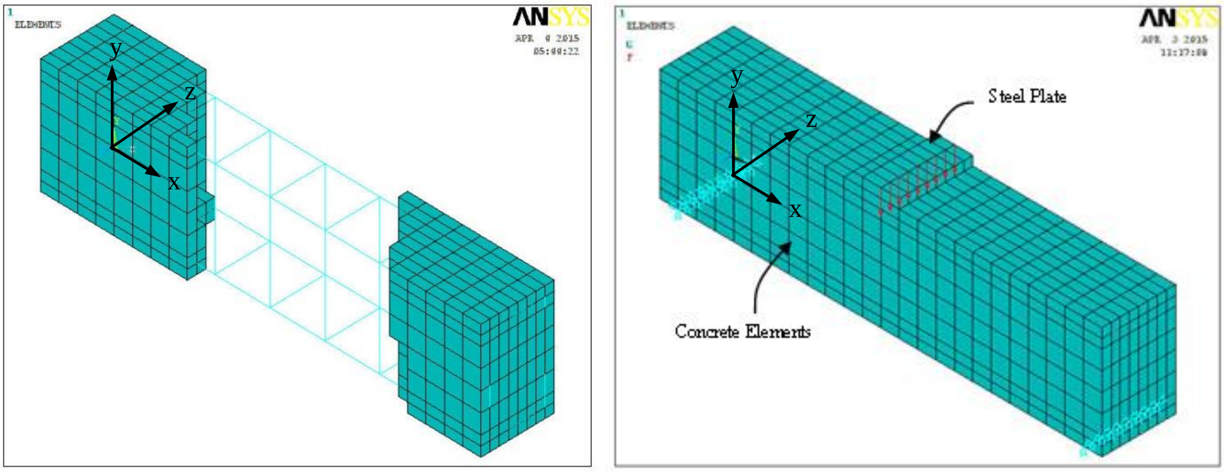

Figure 7. Mesh of the concrete and steel plate.

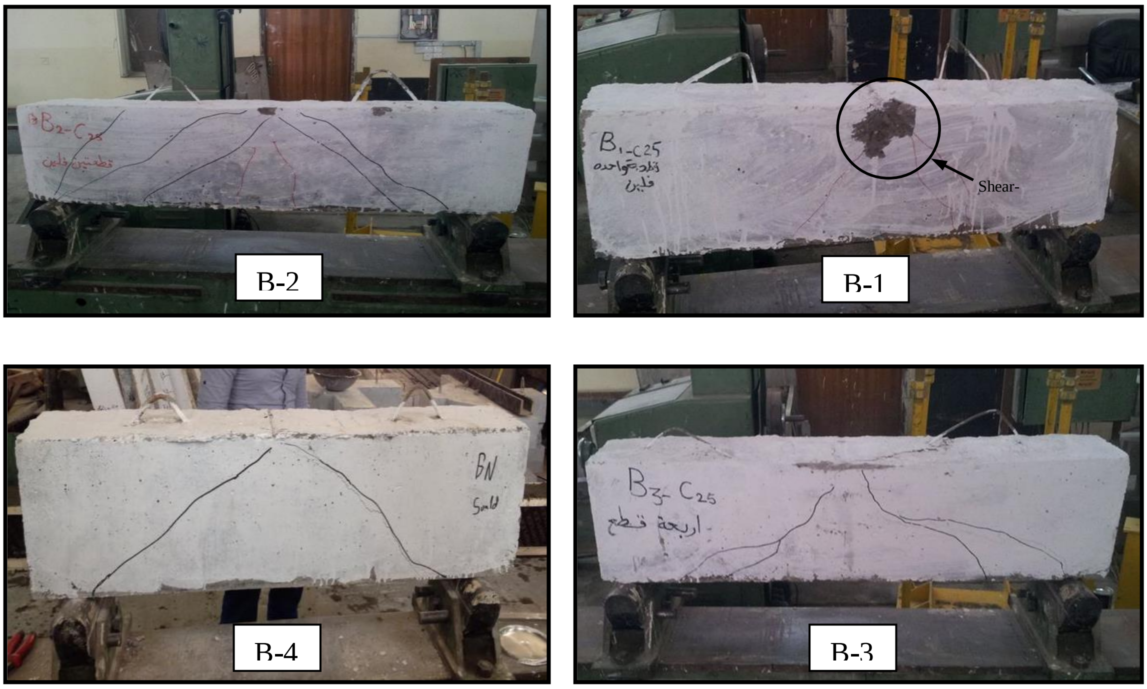

Figure 8. Crack patterns of tested beams.

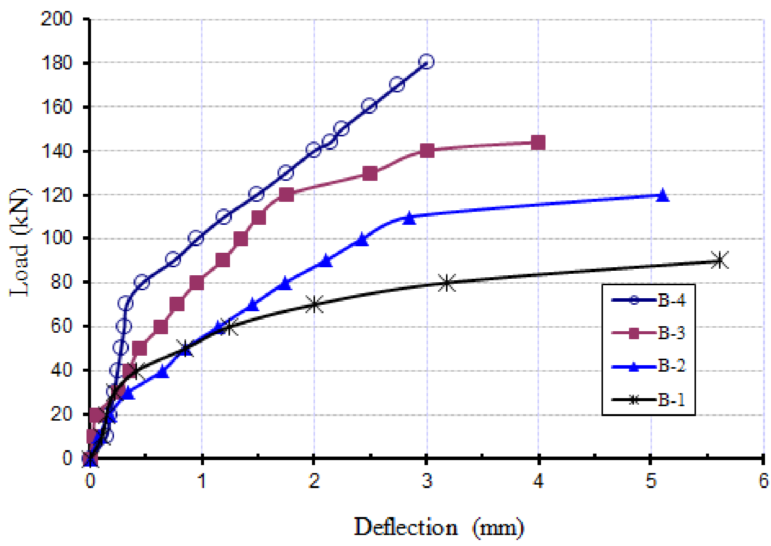

Figure 9. Load-deflection relationship of tested beams.

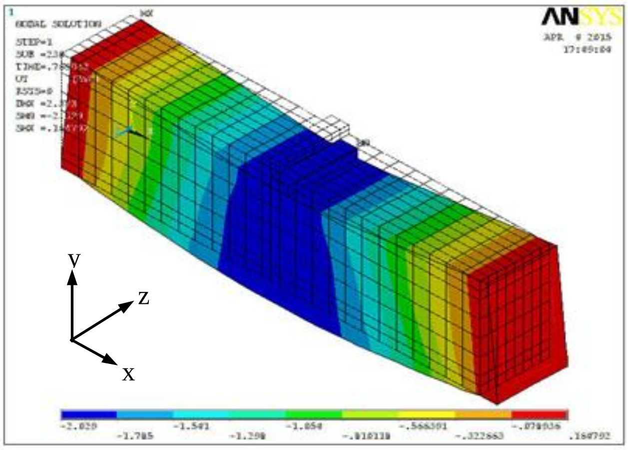

Figure 10. Deflected shape of beam model.

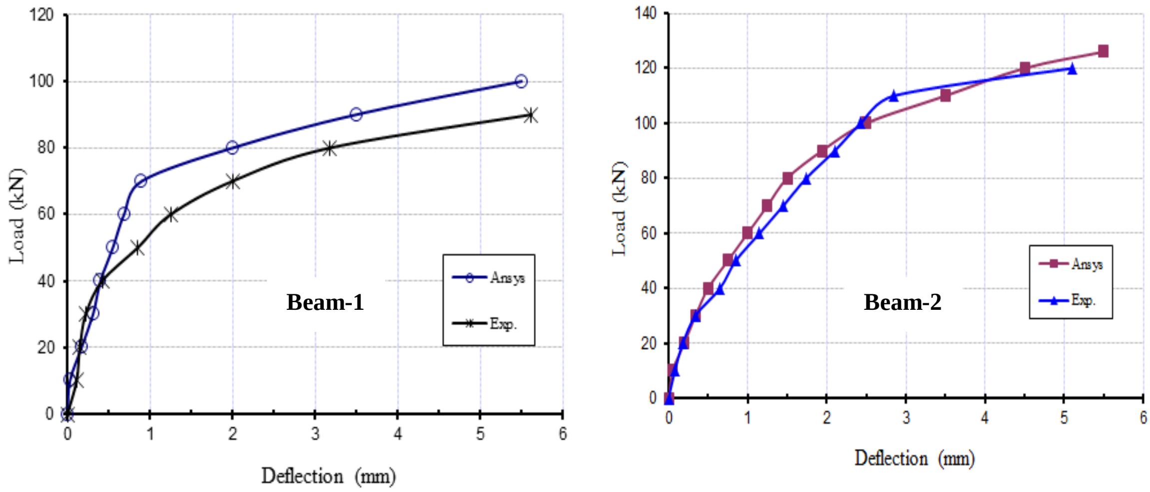

Figure 11. Load-deflection relationship for beam (B-1) and beam (B-2).

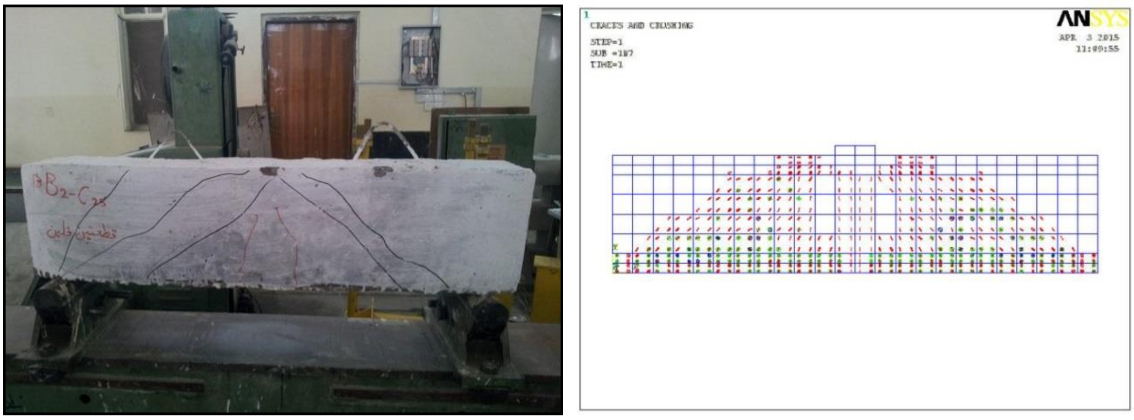

Figure 12. Crack pattern from FE model (right) and experimental tests (left) for B-2.

Table 1. Beams designation and details.

Beam Designation	Dimensions (mm)			Reinforcement		Transverse Ribs **
	b_w	h	l	Flexural	Shear	
(B-1)*	200	300	1200	2 ϕ 12 mm	ϕ 6 mm @150mm	Two (At Ends Only)
B-2						Three Ribs
B-3						Five Ribs
B-4						Without Ribs (Solid)

*Reference Beam **(50mm) thickness

Table 2. Construction materials description.

Material	Descriptions
Cement*	Ordinary Portland Cement (Type I)
Sand**	Natural sand from Al-Ukhaider region with maximum size of (4.75mm)
Gravel**	Crushed gravel with maximum size of (12mm)
Water	Clean tap water (used for both mixing and curing)

* Conform to **Iraqi specification No. 45/1989**. ** Conform to **Iraqi specification No. 45/1984**.

Table 3. Steel bars properties.

Nominal Diameter (mm)	Bar Type	f_y^* (MPa)	f_u (MPa)	Elongation %
4	Plain	461	633	16
6	Deformed	383	545	11
12	Deformed	860	915	16

***** Average of three samples (Each 400mm length)

Table 4. Proportions of concrete mix.

Parameter	Quantity
Water/cement ratio	0.40
Water	168 Liter
Cement	420 kg/m^3
Fine Aggregate	600 kg/m^3
Coarse Aggregate	1200 kg/m^3

Table 5. Mechanical properties of concrete

Property (MPa)	Value (MPa)
Cube compressive strength (f_{cu}) *	30
Cylinder compressive strength (f_c')**	24.6

*Average of three samples. ** f_c' =0.82 f_{cu}

Table 6. Modulus of elasticity and tensile strength adopted in FEA.

Empirical Equation	f_c' (MPa)	Value (MPa)	Note
$E_c = 4700\sqrt{f_c'}$	24.6	E_c =23311	ACI-318
$f_t = 0.62\sqrt{f_c'}$		f_t=3.08	

Table 7. Ultimate shear strength of tested beams.

Beam Designation	P_u (kN)	P_c (kN)	V_u (kN)** (kN)	$(V_u)_i/(V_u)_R$ (%)	Mode of Failure
(B-1)*	90	15	45	1.0	Shear-Compression
B-2	120	20	60	1.33	Shear-Compression
B-3	144	24	72	1.6	Shear-Compression
B-4	180	25	90	2.0	Shear-Compression

*Reference Beam **$V_u = P_u/2$

Table 8. Comparison between experimental and finite element ultimate loads.

Beam Designation	Ultimate Load (kN)		$\frac{(P_u)_{FEM}}{(P_u)_{EXP.}}$
	$(P_u)_{EXP.}$	$(P_u)_{FEM}$	
B-1	90	99	1.1
B-2	120	126	1.05

Deterioration Model for Sewer Network Asset Management in Baghdad City (case study Zeppelin line)

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ABSTRACT

Asset management involves efficient planning of economic and technical performance characteristics of infrastructure systems. Managing a sewer network requires various types of activities so the network can be able to achieve a certain level of performance. During the lifetime of the network various components will start to deteriorate leading to bad performance and can damage the infrastructure. The main objective of this research is to develop deterioration models to provide an assessment tool for determining the serviceability of the sewer networks in Baghdad city the Zeppelin line was selected as a case study, as well as to give top management authorities the appropriate decision making. Different modeling techniques were used based on statistical methods such as discriminant, and artificial neural network (ANN) which were used to build the deterioration models. The results of the discriminant model gave correct classification of 68.9% for the condition class of this line. The main significant influencing variables that play an important role in sewer networks were: sewer age, planning, performance and maintenance which is known as the Management function. From ANN model the confusion matrix gave correct classification of 76.7% and MSE 0.128.This study providing a good source of information for future planning.

Key words: asset management, deterioration, discriminant, artificial neural network, sewer condition.

نموذج ادارة تدهور شبكات المجاري لتطوير خدماتها في مدينة بغداد (خط زبلن حالة دراسية)

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الخلاصة

إدارة الشبكات تشمل التخطيط الفعال وقياس الاداء في كافة المجالات الاقتصادية والتقنية لأنظمة البنية التحتية. إدارة شبكة الصرف الصحي تتطلب أنواع مختلفة من الفعاليات وبالتالي فإن الشبكة يمكن أن تكون قادرة على تحقيق مستوى معين من الأداء. وخلال فترة عمل الشبكة ستبدأ المكونات المختلفة في التدهور مما يؤدي إلى سوء الأداء ويمكن أن تؤدي الى فشل في البنية التحتية. ان الهدف الرئيسي من هذا البحث هو بناء وتطوير نماذج تدهور لتوفير أداة تقييم وتحديد خدمية لشبكات الصرف الصحي في مدينة بغداد بالإضافة الى اعطاء الادارات العليا اتخاذ القرار المناسب. واستخدمت تقنيات نمذجة مختلفة استنادا إلى الأساليب الإحصائية مثل ألتمايز وتحليل

الشبكات العصبية الاصطناعية لبناء نموذج التدهور. وقد تم اختيار خط زبلن الرئيسي الناقل للصرف الصحي في مدينة بغداد كحالة دراسية. أعطت نتائج نموذج التمايز تصنيفا لحالة الصرف الصحي بنسبة 68.9%. وكانت المتغيرات الهامة الرئيسية التي تؤثر في الصرف الصحي لخط زبلن هي ألعمر ، التخطيط ,الأداء والصيانة وتسمى بدالة الادارة. ومن تحليل الشبكات العصبية الاصطناعية فان مصفوفة التداخل أعطت تصنيفا 76.7% ومربع خطا 0,128 .هذه الدراسة تعتبر مصدر مهم للبيانات والمعلومات تفيد في التخطيط المستقبلي.

الكلمات الرئيسية : ادارة الاصول ,التمايز ، التدهور , الشبكات العصبية ألاصطناعية حالة انبوب الصرف .

1- INTRODUCTION

The sewage network system is a key part of the urban infrastructure, which should work accurately and to maintain at a prudent, planned manner, sustainable and based on a scientific basis ,**Baik et al., 2006**. However, many cities suffer because of the infrastructure sewer deterioration that leaves the communities in a difficult psychological suit and disrupt not only sanitation services but other events which are related to people service **,Ana and Bauwens, 2007**. Large parts of sewer networks have already been replaced by newer materials, but in some cities there are still parts of the 19th century sewer in use. In Iraq and distinguish in Baghdad city most of the existing network was built in the second part of the 20th century. Many parts of the sewer networks have been deteriorated therefore they will need to be replaced, repaired or renovated in order to guarantee their required performance and to avoid possibility of failure. Deterioration models can make a significant contribution towards developing proactive management plans and to identify the significant factors that affect the condition of the sewer networks. These factors can be considered during different stages (design, construction and operation) of the project.

Dulcy et al., 2002 presented a description of improved methodology for careful analysis and interpretation of data in sewer systems. The proposed methodology allows fast and accurate assessment, which is important in building sewer asset management database.

Ana and Bauwens ,2007 presented a sewer asset management decision-support tools.. Each tool is qualified and its conforming information requirements are determined. They looked into cases of framing the use of the present available tools and presented a forestation on further research needs in the field.

Tran ,2007 developed hydraulic and structural deterioration models that can predict the conservation status of the sewerage with respect to population expectation. The output of the models may be used for long term annual budget and prioritizing maintenance.

Ana ,2009 studied the contribution of two important concepts in sewer network asset management. The research reported a significant grade in the progression and use of sewer construction deterioration models found on the regression Markov of semi, logistic analysis and multi criteria decision making (MCDM) in prioritizing sewer rehabilitation projects.

Sophie et al., 2013 a censored model (survival) was progressed to forecast total structural condition of a sewer by using camera examining outputs. The deterioration model was advanced to get the survival age. The e^x and Wiebul equations were used to stand for the division of ages in each deterioration condition.

Bouamrane and Bouziane 2014 developed a decision backup to deliver judgments to the problems of networks administration/ repairing, in order to help senior management. They stated that priority of interference may be by computation of three criteria (economic, environment and social) as well as the planning displayed should be well considered.

Even though the condition of Iraq sewer networks is not as good as those in other countries, large problems can be expected in the future if the current approach is not drastically changed. Allocated funds for sewer maintenance and operation are limited and not sufficient to keep the system in good condition.

1-1 Objective of the Study

The main objective of this research is to develop a performance based asset management program to provide an assessment tool for determining the serviceability of the sewer infrastructure system in Baghdad city by building deterioration models. These models are developed using discriminate analysis and artificial neural network. The predictive performance of these models is assessed by adaption of statistical tests and confusion matrix.

2- FACTORS AFFECTING SEWER DETERIORATION

The established knowledge on the mechanisms of sewer structural deterioration and failure along with the factors associated with deterioration should be identified and understood. The occurrence and propagation of defects and the rate of deterioration of pipes are affected by a number of factors.

2-1 Physical Factors

These factors refer to the physical attributes of the sewers:

2-1-1 Age

The construction year affects the sewer condition since it represents the sewer age and the quality of the construction work.

2-1-2 Shape

Among the different shapes in sewer networks, circular sewers are considered the strongest, **Baur and Herz, 2002**.

2-1-3 Diameter

The effect of pipe size on deterioration is rather contradictory across different studies. Some say that small diameter pipes are aging faster than bigger sizes.

2-1-4 Depth

Sewers at depths of less than 2m have higher than average failure rates **Fenner et al., 2000**. In addition **Anderson and Cullen ,1982** reported that 65% of the 4400 sewer failures that they studied occurred at a depth of 2m or less and 25% occurred at a depth from 2 to 4m.

2-1- 5 Length

Typically, long sewer (manhole-to-manhole length) results in higher deterioration rates. Defects in the connecting joints of the sewer pipes are one of the defects that cause the deterioration problems **Park and Lee, 1998.**

2-1-6 Material

There are many advantages and disadvantages using different types of materials in sewer networks. Typically, concrete pipes perform better than other pipes due to their high abrasion resistance, strength and cost **Ana, 2009**. Material types used in the construction of sewer pipes affect their reaction with the environmental **Salman, 2010.**

2-1-7 Slope

The sewers at medium slopes deteriorate slower than sewers with steep slopes where the corrosion rates are high **Ayuob et al., 2004**.

2-1-8 Type

The combined system deteriorates with slower rates compared with the separate network carrying sanitary sewage, **De Toffol et al., 2007.**

2-2 Environmental Factors

These factors refer to the characteristics of the surrounding environment of the sewer systems.

2-2-1 Presence of tree roots

The growth of roots inside the pipe affects the sewage transport. Furthermore roots inside the sewer exert more pressure on the pipe which may break it **Perera et al., 2007**.

2-2-2 Soil/backfill type

WRc ,1994. described fine, cohesive less soils (e.g. silt, fine sand) as highly susceptible to ground loss, where cohesive soils (e.g. coarse sand, gravel) and clay are the opposite,as well as to soil properties , trench side slop and execution methods .

2-2-3 Traffic and surface loadings

Studies have provided evidence that sewers under main roads (heavy traffic) suffer more defects (cracks, fractures) compared to minor roads (light traffic).

2-3 Operational Factors

These factors are related to how sewers operate and function.

2-3-1 Sewer function

One classification for the sewer networks is according to what kind of sewage it may carry. For the combined system the domestic sewage may be diluted with storm water and this could decrease the corrosion process, **Tran, 2007**.

2-3-2 Sewer maintenance

Appropriate maintenance strategies, like sediment removal, sewer cleaning and root cutting generally increase the service life of sewers. Nevertheless, cleaning techniques may accelerate sewer deterioration, **Davies et al., 2001**.

3- MONITORING AND ASSESSING PIPE CONDITIONS

Pipe condition (status) is often used to describe the overall serviceability, i.e. structural and hydraulic capacity of pipes at a point of time in their lifetime. Because of pipe deterioration, the task of monitoring and assessing the changes of pipe condition over time becomes extremely important as part of proactive management strategies. In the current management practice of sewers pipes, this task consists of two steps: 1- selection of inspection techniques and 2- grading conditions **Manu, 2010**. Laser profiling is used in conjunction with closed circuit television (CCTV) as it uses a ring of laser to assess the shape of the pipe wall or any change caused by deformation, sedimentation and corrosion, etc., **Van der Hoop, 2010**.

3-1 Rating Description of Condition

Scale which ranges from excellent to poor was used as the basis of all assessment sewer networks, **Wagga Guide, 2010**.

3-1-1-Excellent condition: Only planned maintenance is required, no defected is detected in the system.

3-1-2 Very good: It requires minor maintenance as well as programmed maintenance and rehabilitation can be scheduled for long term construction.
3-1-3 Good: Significant maintenance is required, rehabilitation is necessary for a medium –term within 3- 5 year.
3-1-4 Poor: Significant renewal/upgrade is required, rehabilitation is keen and must be completed in one - two years, necessary emergency has to be checked**.**
3-1-5 Very Poor: Complete breakdown of the pipe, rehabilitation stringent and short term to prevent collapse is necessary.

4- DETERIORATION MODELS

Many techniques for modeling the deterioration of sewer systems are available some are based on statistical methods such as, the discriminant analysis, and other based on artificial neural networks. The basic data required in the deterioration modeling are the factors mentioned in section 2.These requirements were gained from the data collected from Baghdad Mayoralty.

Table 1 shows the code identification that was used in the models to specify the different independent variables and dependent conditions.

4-1 Discriminant MODEL

Fisher's linear discriminate analysis (LDA) is a statistical method for classifying or predicting individuals or objects into mutually exclusive and exhaustive classes based on a set of independent variables or predictors, **Huberty, 1994**. The goal of this model is to get a linear transformation of independent variables which represent the maximum proportion amidst the within scatter class, **Laitinen, 2007**. Modeling needs to consider classification models that search for any exist or potential separation between groups centers of the variables of interest. Clear separation of the group's center indicates the goodness of the considered set of independent variables in the interpretation of the variability between groups of the variable condition. The classification models (Discriminant analysis) consider highly correlated sets of independent variables. The matrix of the correlation coefficients between the continuous variables was obtained by using SPSS program. The information gathered for this case study was subjected to statistical analysis in order to provide scientific evidences about modeling the variables of interest.

4-2 Artificial Neural Networks (ANN) Model.

In the case of sewer deterioration modeling, neural networks investigate the mathematical relationships between predictors (independent variables, i.e. deterioration factors) and responses (dependent variables, i.e. discrete sewer condition classes), **Kley et al., 2013**. Each connection between neurons has an associated weight that is determined by minimizing fault between the predicted output and the real output values.

5- CASE STUDY: ZEPPELIN SEWER TRANSPORTATION LINE

This line is one of the main sewers that collect sewage from Alrusafa side in Baghdad city. This sewer is about 25400 m in length and starts from the municipality of Al- Shaab and ends at Alrustamiya waste water treatment plant (3^{rd} expansion) south of Baghdad. This sewer starts with diameters of 1800 to 2400 mm at depths of 3 to 7 m and ends at 3000 mm in diameter with 6 to 10 m in depth at the plant. This main line is clogged at rates ranging from 40% to 80% by oil, industrial wastes, trash, sediment and mud, knowing that this problem is one the most complex problems facing the drainage systems and requires fast and effective solutions.

5-1 Discriminant Model

The dependent variable (condition of the sewer) has only four rating conditions instead of five. The excellent condition was not recorded. **Table 2** shows the matrix of simple linear correlation coefficients for the set of variables in this region. With respect to the test of significant, the variables age, diameter, and length were found to be not significant linearly correlated, therefore will be considered in the Discriminant model. It is clear from the discriminant model shown in **Fig.1**, that the group centroids are well separated from each other but there is an over lapping of the category Good with cases of Very good and Poor categories. This is an indication that some of the remaining variables may help enhancing the classification and the total correct classification was found to be 68.9%. Different trials were made in order to decide on the set of categorical factors. The results revealed that all the variables are to be used as independent variables in the analysis and their contribution explains the dependent variable (condition). **Fig. 2** shows the merged groups centroids which reflect a better separation than that shown in **Fig.1**. This figure shows that cases of the Good category are still not well separated whereas all of the other three categories are very well separated.

The Box's M test, **Table 3** shows that the equalities of covariance matrices are significantly different and Table 4 shows the summary of the canonical correlations. In this situation the first function explains about 78.5% of the variance in the dependent variable that represent the square high correlation$(0.886)^2$.

Table 5 shows the output of the Wilks' test which also indicates that the condition categories are significantly different from each other.

The standardized canonical discriminates of the function coefficients are shown in **Table 6**. From this table, sewer age contributes to the maximum variance in the condition of the sewerage network. It can be used as a threshold to enhance the efficiency of the sewer pipe. Planning was found highly contributed to the dependent variable variance appeared by the second discriminant function. Moreover material was found also highly explained by the third function. According to the structure matrix **Table 7**, function 1 can be named as the age function since age has the largest absolute value among other independent variables. Function 2 can be named as the planning function and function 3 can be named as the material function.

Table 8 shows the group centroids which can be used as a reference when judging or predicting new cases. **Table 9** shows the unstandardized coefficients of the canonical discriminant functions which are used to build the actual prediction equation using new cases for classification. The classification matrix and Jack-Knife cross validation of this model ,**Table10** shows that condition 1 (Very good) has a 100% of correct classification. This is an indication that the discriminant function is very robust in detecting cases of this group. The condition categories Poor and Very poor are also well separated and they have percent of correct classification 83.3 and 93.5% respectively.

5-2 Artificial Neural Networks (ANN) Model.

Artificial neural network (ANN) was used here in order to enhance the results of the previous analysis of sewerage conditions. MATLAB programming environment provides very powerful procedures for implementation of such techniques. ANN is not always the procedure of choice in cases where there is no consistency between input and target sets of data. In order to compare the results of ANN to that of the Discriminant analysis, the MATLAB ANN was used. Out of the input and target sets of data, the MATLAB program will extract three samples of data called training, validation and testing. The most common activation function is the sigmoidal function which may be defined as follows:

$$Y = F(S) = \frac{1}{1 + e^{-S}} \quad (1)$$

In the back propagation learning occurs in the perceptron by changing connection weights after each piece of data is processed, based on the amount of error in the output compared to the expected result. In the case of supervised learning carried out through back propagation, error in output node is actually the difference between the target (TY) value and output value obtained by the net (Y). That is:

$$e=TY-Y \quad (2)$$

Accordingly, corrections to the weights of the nodes must be made in order to minimize the error in the entire output. This is a procedure that can be done by using different functions like gradient descent, gradient descent with momentum, and scaled conjugate gradient which is the case of this research work.

The scaled conjugate gradient algorithm (SCG), was designed to avoid the time-consuming line search. This algorithm is too complex to explain in a few lines, but the basic idea is to combine the model-trust region approach (used in the Levenberg-Marquardt algorithm described later), with the conjugate gradient approach. **Table 11** shows the default values of scaled conjugate gradient function. The default number of hidden neurons is set to 10. One might want to come back and increase this number if the network does not perform as well as he/she expect. The number of output neurons is set to the number of categories of the target data. In this context, **Fig. 3** shows the first diagram of the neural network used in this research for the data of Zeppelin line.

If the provided data is not large enough, then it is not expected that ANN will lead to meaningful or good results. Pattern recognition tool is also a classification procedure, was used to produce alternative classifications. Almost all confusion matrices revealed approximately the same percentages of correct classifications reaching 76.7% ,**Fig. 4**. The Mean Squared Error (MSE) is about 0.128 as shown **Fig. 5** and the error histogram ,**Fig. 6** is also well distributed around zero. The neural network analysis showed that the condition classes are overlapped and that they are not really five classes but maybe three or four classes.

6-CONCLUSIONS

Continuous inspection of any sewer network including pipes, manholes and pumping stations is necessary to provide the required maintenance as soon as possible. Training the technical staff will help in improving the ability of the workers for good management of technical problems. Deterioration models will help to predict the asset condition and a critical management decision can be made. In this study deterioration models were developed for the Zeppelin line in Baghdad city. The Discriminant and Artificial neural network models were used for the development of these models. The main conclusions achieved regarding these models are:

6-1 Discriminant Analysis

The condition variables were designed to have five distinguished classes; it appeared that these classes are actually four or sometimes three. Mostly these classes were Good, Poor and Very poor. Moreover, sewer age was the most significant variable in the evaluation process of the sewerage network condition. Planning (management function) appeared to have influence on judging the condition of this line where material also had some influence. The cross-validate grouped cases correctly classified was 68.9% .

6-2 Artificial Neural Network (ANN)

ANN has a remarkable ability to derive facts (target) from complicated or imprecise sets of data (inputs). Pattern recognition tool was used for classification of the condition classes. The percentage from the confusion matrix was 76.7% and MSE from the error histogram was 0.128 which indicates the goodness of the model in classifying new cases. Error histogram shows that the errors are distributed approximately equally around zero, this is indication of the goodness of fit for the ANN model. Continuous inspection and maintenance of this line, manholes and pumping stations are required as soon as possible for better performance.

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List of Abbreviations

ANN Artificial Neural Network

LDA Linear Discriminate Analysis -

GRP Glass Fiber Reinforced Plastic (GRP) Pipes

PVC Polyvinylchloride Pipes

CCTV Closed Circuit Television

MSE Mean Squared Error

Table 1. CODE Summary of the sewer network**.**

Data	Measurement type	Codes
Condition	Ordinal	excellent (condition1),very good (condition 2) , good (condition 3) , poor (condition 4) , very poor (condition 5)
Sewer type	Nominal	1-Gravity sewer, 2- pressure sewer
Sewer shape	Nominal	1-circular , 2- rectangular
Sewer function	Nominal	1-combined system ,2-separate system
Age	Scale (year)	
Diameter	Scale (mm)	
Depth	Scale (m)	
Length	Scale (m)	
Slope	Scale(m)	
Tree roots	Scale (number)	
Traffic	Ordinal	1-low , 2-medium , 3- high
Maintenance type	Nominal	1-rehabilitation , 2-major maintenance, 3-minor maintenance
Performance	Scale	90% (excellent performance), 75% (good performance) 65% (medium performance), 55% (poor performance)
Planning type	Nominal	1-planning long term, 2-planning medium term, 3-planning short term.
Material	Nominal	1-concrete pipe ,2-PVC polyvinylchloride pipe,3-GRP glass fiber reinforced pipe

Table 2. Simple linear correlation coefficient matrix.

		Age	Perform.	Diameter	Depth	Length	Slope
Age	Pearson Correlation	1	-.600**	.101	.092	-.090	-.101
	Sig. (2-tailed)		.000	.312	.355	.366	.311
	No.	103					
Perform.	Pearson Correlation	-.600**	1.0	.066	.040	.080	-.059
	Sig. (2-tailed)	0.000		.509	.686	.422	.552
	No.	103					
Diameter	Pearson Correlation	.101	.066	1.00	.837**	-.064	-.994**
	Sig. (2-tailed)	.312	.509		.0 00	.524	.00
	No.	103					
Depth	Pearson Correlation	.092	.040	.837**	1.0	.035	-.808**
	Sig. (2-tailed)	.355	.686	.000		.725	.0
	No.	103					
Length	Pearson Correlation	-.090	.080	-.064	.035	1 .00	.091
	Sig. (2-tailed)	.366	.422	.524	.725		.363
	No.	103					
Slope	Pearson Correlation	-.101	-.059	-.994**	-.808**	.091	1 .0
	Sig. (2-tailed)	.311	.552	.000	.000	.363	
	No.	103					

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3. Equalities of covariance matrices.

Box M		74.188
F	Approximate	1.787
	d.f1	36
	d.f2	13554.221
	Significance.	.003

Table 4. Summary of the canonical correlation.

Functions.	Eigen. value	% of variance.	Cum. %	Canonical Correlation.
1	3.6390[a]	90.60	90.6	.886
2	.3009[a]	7.7	98.3	.486
3	.069[a]	1.7	100.	.254

a. First 3 canonical discriminant functions were used in the analysis.

Table 5. Wilk's, Lambda test.

Test Function (s)	Wilks' Lam.	chi-square	df	Sig.
1.0 through 3.0	.154	179.603	24	.000
2.0 through 3.0	.714	32.287	14	.004
3.0	.935	6.412	6	.379

Table 6. Standardized canonical discriminant coefficients.

	Function 1	Function 2	Function 3
Age	-1.004	.065	-.157
Dia.	.590	.322	.631
Length	-.013	.034	-.414
Traffic	.534	.028	-.179
Tree roots	.201	-.005	-.353
Maintenance	.110	-.248	.174
Planning	-.143	.885	-.116
Material	.297	.098	.968

Table 7. Structure matrix.

	Function 1	Function 2	Function 3
Age	-.883*	.191	-.033
Planning	.067	.963*	-.034
Diameter	.009	.634*	.167
Material	-.049	-.304	.545*
Tree roots	.091	.142	-.455*
Traffic	.208	.000	-.440*
Maintenance	.031	.136	.233*
Length	.062	-.151	-.190*

*. Largest absolute correlation between each variable and any discriminant function

Table 8. Functions at group cancroids.

Cond.	Function		
	1	2	3
1.00	3.573	.579	.548
2.00	1.407	.316	-.370
3.00	.071	-.738	.044
4.00	-2.416	.405	.082

Unstandardized canonical discriminant functions evaluated at group means

Table 9. Coefficients of the discriminant functions.

	Function 1	Function 2	Function 3
Age	-.402	.026	-.063
Dia.	.001	.001	.001
Length	.000	.002	-.026
Traffic	.650	.035	-.217
Tree roots	.227	-.005	-.400
Maintenance	.174	-.393	.276
Planning	-.179	1.111	-.145
Material	.935	.307	3.042
(Constant)	8.610	-4.750	-2.136

Unstandardized coefficients

Table 10 . Classification matrix and jack-knife cross validation [b,c].

		Cond.	Predicted Group Membership				Total
			1.0	2.0	3.0	4.0	
Originally	Count	1.00	10	0	0	0	10
		2.00	6	14	4	2	26
		3.00	0	5	30	1	36
		4.00	0	0	2	29	31
	%	1.00	100.0	.0	.0	.0	100.0
		2.00	23.1	53.8	15.4	7.7	100.0
		3.00	.0	13.9	83.3	2.8	100.0
		4.00	.0	.0	6.5	93.5	100.0
Cross-validation [a]	Count	1.00	7	3	0	0	10
		2.00	6	11	7	2	26
		3.00	0	7	26	3	36
		4.00	0	1	3	27	31
	%	1.00	70.0	30.0	.0	.0	100.0
		2.00	23.1	42.3	26.9	7.7	100.0
		3.00	.0	19.4	72.2	8.3	100.0
		4.00	.0	3.2	9.7	87.1	100.0

a. Cross validation is done only for those cases in the analysis
b.. 80.6% of origin group cases correctly classified.
c.. 68.9% cross-validated grouped cases correctly classified.

Table 11. Default values of the function trainscg.

Epochs	100	Maximum number of epochs to train
Show	25	Epochs between display (NaN for no displays)
Time	Inf	Maximum time to train in seconds
min_grad	1-e6	Minimum performance gradient
max_fail	5	Maximum validation failures
Sigma	5.0e-5	Determine change in weight for second derivative approximation
Lambda	5.0e-7	Parameter for regulating the indefiniteness of the Hessian

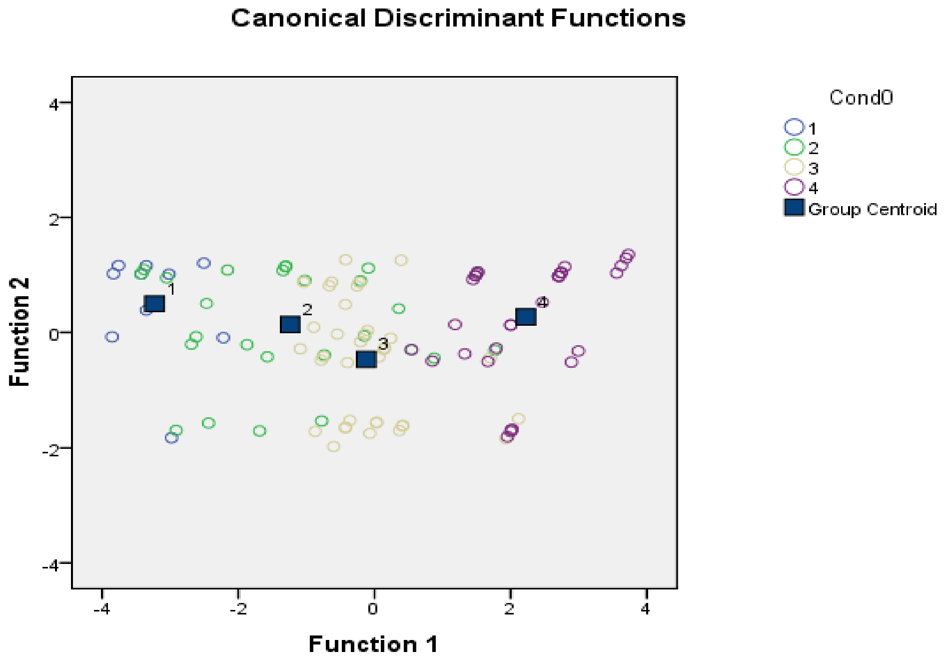

Figure1. Canonical discriminant functions applied to the data of region.

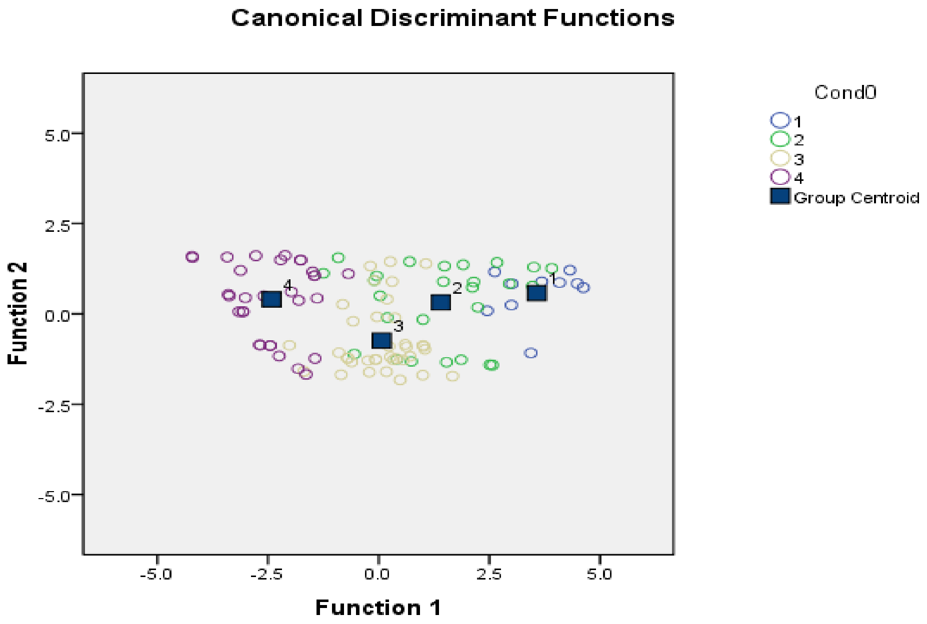

Figure 2. Canonical discriminant functions applied to the merged data of the region.

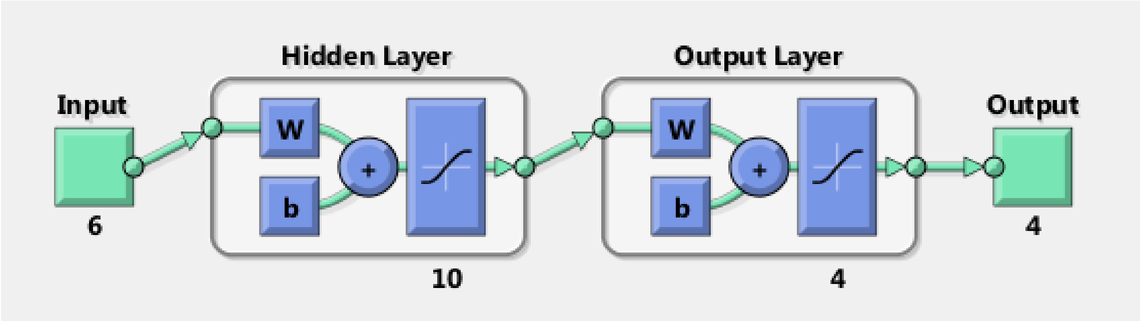

Figure 3. The first diagram of neural network.

Figure 4. Confusion matrices of the Zeppelin line.

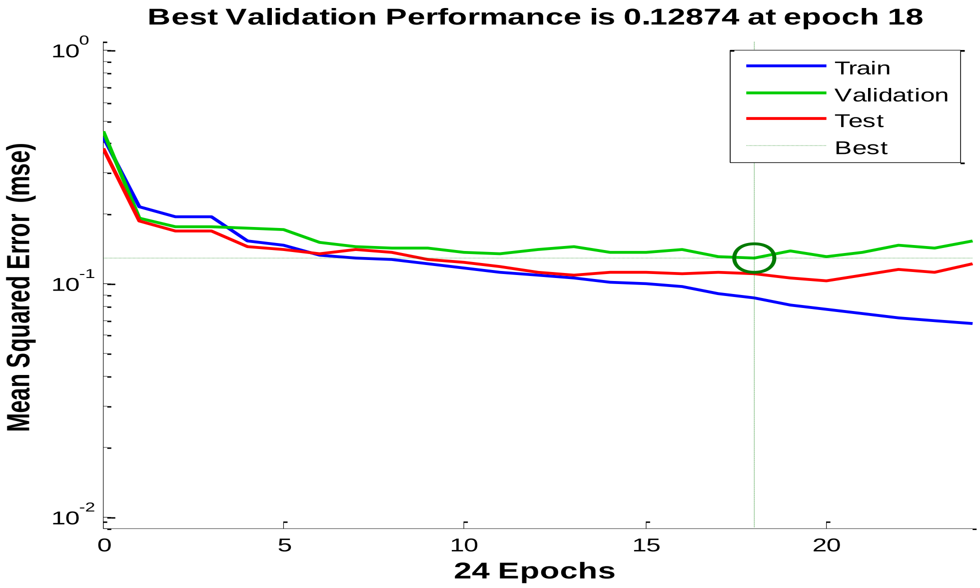

Figure 5. MSE of the ANN model for the Zeppelin line.

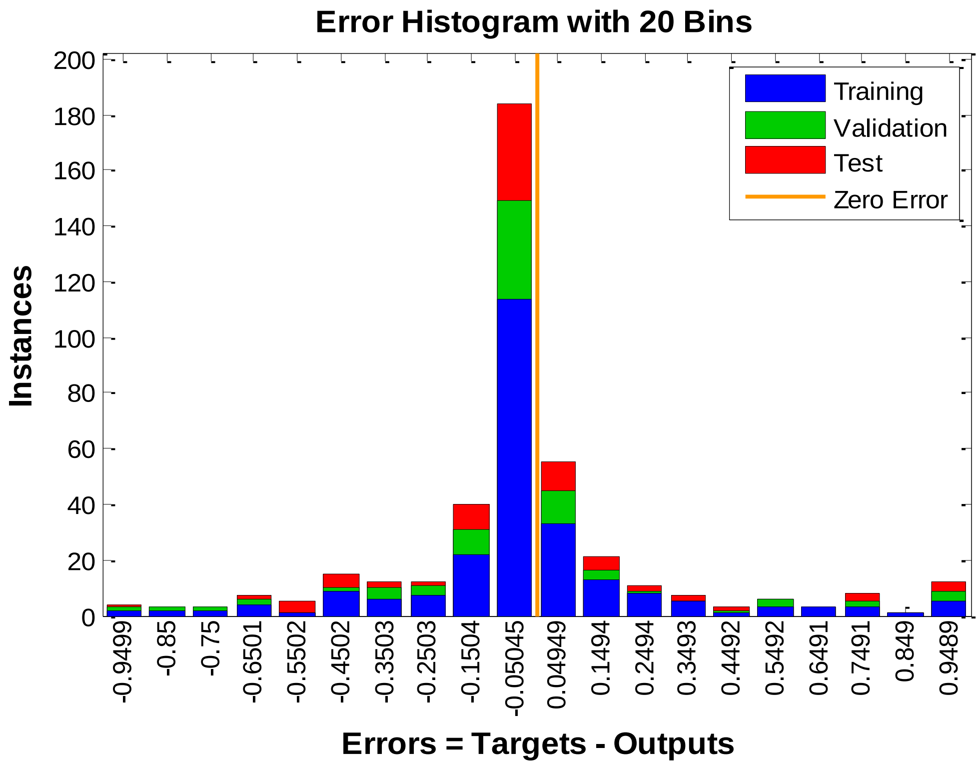

Figure 6. Error histogram of the outputs of ANN model.

Impact of Different H/D Ratio on Axial Gas Holdup Measured by Four-Tips Optical Fiber Probe in Slurry Bubble Column

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ABSTRACT

In wide range of chemical, petrochemical and energy processes, it is not possible to manage without slurry bubble column reactors. In this investigation, time average local gas holdup was recorded for three different height to diameter (H/D) ratios 3, 4 and 5 in 18" diameter slurry bubble column. Air-water-glass beads system was used with superficial velocity up to 0.24 m/s. the gas holdup was measured using 4-tips optical fiber probe technique. The results show that the axial gas holdup increases almost linearly with the superficial gas velocity in 0.08 m/s and levels off with a further increase of velocity. A comparison of the present data with those reported for other slurry bubble column having diameters larger than 18" and H/D higher than 5 indicated that there is little effect of diameter on gas holdup. Also, local section-average gas holdups increase with increasing superficial gas velocity, while the effect of solid loading are less significant than that of superficial gas velocity.

Key words: slurry bubble column, gas holdup, optical probe.

تأثير النسب المختلفة للارتفاع إلى القطر على المحتوى الغازي المحوري المقاس بواسطة المجس البصري ذو النهايات الأربعة في العمود الفقاعي الذي يحتوي على صلب

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الخلاصة

لمدى واسع من العمليات الكيمياوية و البتروكيمياوية و عمليات الطاقة ليس من الممكن الاستغناء عن مفاعلات الأعمدة الفقاعية ذات المحتوى الصلب. في هذا البحث, تمت دراسة معدل المحتوى الغازي ألموقعي لثلاث نسب مختلفة من الارتفاع إلى قطر المفاعل و هي 3 و 4 و5 لقطر مفاعل مقداره 18 انج. استخدم نظام هواء – ماء – حبيبات زجاجية و سرعة الغاز تصل إلى 0,25 م/ثا. تم قياس المحتوى الغازي باستخدام تقنية المجس البصري ذو النهايات الأربعة. بينت النتائج أن المحتوى الغازي المحوري يتزايد تقرباً بشكل مستقيم مع زيادة سرعة دخول الغاز عند 0,08 م/ثا و تستقر مع زيادة سرعة دخول الغاز. إن مقارنة النتائج مع باحثين آخرين عملوا على مفاعلات فقاعية بمحتويات صلبة ذات أقطار اكبر من 18 انج و نسبة ارتفاع إلى قطر أعلى من 5 بينت انه يوجد تأثير محدود لقطر المفاعل على المحتوى الغازي. أيضاً, و جد أن متوسط المحتوى الغازي للمقاطع يزداد مع زيادة سرعة الغاز السطحية في حين أن تأثير تركيز الصلب هي اقل أهمية من سرعة الغاز السطحية.

الكلمات الرئيسية: العمود الفقاعي ذو العالق الصلب, المحتوى الغازي, المجس البصري.

1. INTRODUCTION

slurry bubble column reactors have been considered as very important and promising technologies in multiphase operations such as biological waste water treatment, flue gases, desulphurization, Fischer–Tropsch synthesis, fermentation production of ethanol and mammalian cells and hydro–treating of heavy petroleum, **Larson,** and **Tingjin, 2003**, **Azzopardi, et al., 2011, Prakash, et al., 2001**. The hydrodynamics and reaction kinetics play a major role in the selection, design, size and performance of these reactors. Since, the reaction regimes are highly affected by phase holdup and mass transfer which are needed to maintain the gas concentration in the reaction regimes at certain level, that sustain the reaction progress. While, it should be interested to study low ratios of H/D as it is used in bulk industrial applications, most published data are obtained in small column diameters, with H/D ratio greater than ten times.

Some researchers reported that the overall gas holdup is not affected when the H/D ratio above 5, **Parasu,** and **Joshi, 2000**. Numerous authors reported that, in homogeneous regime, the overall gas holdup is independent on the column diameter when it is greater than 0.15m (except for highly viscous solution), **Joshi, et al., 1998,** and **Shah, et al., 1982**. In general, all papers dealing with column size reported that liquid recirculation and back-mixing increases strongly with column diameter, **Krishna, 2000, Baird,** and **Rice, 1975, Towell,** and **Ackerman, 1972**. However, the data reported in open literatures are disordered and have to be assessed and validated at different conditions and scaling up design parameters, **Forret, et al., 2006**.

Recently, the data which has been published in literatures of several investigators, **Vandu,** and **Krishna, 2004, Chilekar, 2007**, **Yu, et al., 2012**, is also in agreement with the proposed influence of the column diameter on the hydrodynamics of the slurry bubble column which is in same trend with the previously work of, **Shah, et al., 1982**. They revealed that the gas hold-up decreases with increase in the column diameter up to 15cm (5.9") due to increase in liquid re-circulations. Above 15cm diameter there is no influence of column diameter on the measured gas hold-up up to 5.5 m column diameter. On the other hand, they did not report how the variation are under different solid loading and low H/D ratios which are essential to achieve reliable figuring out for scaling up of industrial applications. The lack of complete understanding of the hydrodynamics of bubble columns under this range of H/D ratios makes it difficult to improve their performance by right selection and control of operation parameters.

The main objective of this research is to focus on the measurements of hydrodynamic parameters using four tips optical fiber probe and evaluate the impact of scale and solid loading on the hydrodynamics of slurry bubble column.

2. EXPERIMENTAL WORK

A large scale Plexiglas column of 18" (45cm) diameter and 115" (292 cm) length was used as a test contactor in this research, as shown in **Fig.1**. The column was supported by firm steel structure to keep it vertical and minimize the vibrations which might affect the measured gas holdup signals. All experiments were carried out using filtered tap water and oil free compressed air. A perforated plate was used as a distributor with 1.09% open area (area of open holes to total area of plate), 241 holes of 3mm diameter placed in a square pitch. The gas flow rate was regulated by two rotameters to cover the range of flow and the water was used in batch mode with varied hydrodynamic height above the distributor according to the H/D ratios used throughout the experiments in the range of 3 to 5. Glass beads particles of 150 μm and 2430 kg/m^3 density were used as suspended solids with loading of 0, 9 and 20%. The glass particles were mixed with tap water over night to ensure complete wetting and good liquid distribution throughout the experiments. Four – tips optical probe was used to obtain the hydrodynamic measurements. The technical and working details were described elsewhere, **Youssef, 2010**. Local probe measurements were taken at five different axial positions (14, 28, 42, 56 and 70") at the center of the column when the probe tips facing downward. It is well known that the gas holdup measured by the probe, which is time based, is little different from the overall volume based gas holdup, that is commonly used. The overall gas holdup based on volume ratio is defined as the fraction occupied by gas in multiphase system which is measured using the bed expansion method. The local gas holdup obtained by the probe is defined as:

$$\varepsilon_{g,t} = \frac{t_g}{t} \qquad (1)$$

where, t_g is the time which the probe spends in the gas phase and t is the total measuring time, **Xue, 2004**.

3. RESULT AND DISCUSSION

The profiles of axial gas hold up were obtained from the measured signals of optical fiber probe at different slurry concentrations and several ratios of H/D. Three main regions can be distinguished to the axial gas holdup profile in slurry bubble column. These are mainly categorized as: the distributor region which is near the column bottom, the bulk region and the foam or disengagement region at the top of the column, **Gandhi, et al., 1999**. The relative size and magnitude of each region would vary depending on operating conditions. In general, gas holdups were low near the distributor region, relatively constant in bulk region and high in the top region. These observations are generally in agreement with literatures.

3.1 Effect of H/D ratio on gas holdup

The effect of H/D ratio and suspended solid concentration on axial gas holdup for three superficial gas velocities 0.08, 0.16 and 0.24 m/s. are properly illustrated in **Fig. 2** to **4**. It is worth mentioning, from visual observation that the glass beads blocked some of distributor holes leading to plume formation during the bubbling of gas in the column near the entrance zone. This phenomenon led to an earlier regime transition, and decreased the gas holdup. Thus, the low values of gas holdup that is observed near the distributor could be attributed to a fouled distributor plate and there will be a negligible effect of coalescence behavior of bubbles as supported by other researchers, **Chilekar**, **2007**. **Gandhi, et al., 1999** reported that the gas holdup in the distributor region is a net result of the bubble formation, bubble coalescence and bubble breakup hence, the probe response does not increase substantially throughout this zone.

In the next region i.e. the bulk zone, the behavior of bubbles became more uniform throughout the experiments due to the higher pressure drop across the distributor, hence the gas was bubbling uniformly though the holes over the distributor region. Moreover, gas holdups measured in the column with 0% and 9% solid loading are slightly different at H/D of 3 and 4, this result is in agreement with the conclusion revealed by, **Lau, et al., 2009**. The influence of the distributor is expected to extend up to an axial height of about 0.7m and beyond that, higher gas holdup was be achieved through the bulk region and the maximum values were recorded at the top of the column specially when the H/D ratio equals five. It was also noticed, the increase in superficial gas velocity enhanced the local gas holdup as shown in **Fig. 3** and **4**. The main presence of gas holdup in the distributor region comes from gas bubbles which were drifted by the high circulation of slurry resulting from the higher gas velocity. Also, it was clearly noticed from the above mentioned figures that the gas holdup in the above regions (bulk and the top) is much higher especially at gas velocity 0.24m/s comparing with lowest gas velocity i.e. 0.08m/s. This observation is agreed with other researches like, **Forret, et al., 2006**. They explained that the circulation bubbles may enter the bottom region from the minimum resistance path, and the presence of the gas distributor dispatch most gas bubbles to the upward direction which enhances the gas holdup in the above regions.

3.2 Effect of superficial gas velocity

The variation of local gas holdup with superficial gas velocity at different solid concentrations were illustrated in **Fig. 5**, **6** and **7**. From these figures, it is evidently shown that gas holdup is increasing continuously with increasing of superficial gas velocity at all slurry concentrations from 0 – 20%. These increments are very slow and slight in the distributor zone especially when the slurry concentration is elevated to 20%, but in general there is no significant change in gas holdup under these conditions as shown in **Fig. 5**.

On the other hand, an obvious increase in gas holdup at bulk and top regions for all solid concentrations was found but it was decreasing with increasing the loading concentration till it reached the lowest values at 20% concentration. This may be attributed to the reduction in bubble break-up due to increasing suspension viscosity and this is compensated by availability of larger bubbles which have higher breakage rate as agreed with, **Prince,** and **Blanch, 1990**. Such an increment in gas holdup was not recorded at low gas velocities for example in 0.08m/s, but it was a distinguishable increase in gas holdup at higher gas velocities from 0.16 to 0.24 m/s in bulk and progressively in the top regions due to the high gas holdup in the top region which extended further down the column at higher gas velocities. While the increment of slurry concentration has incompatible effect with gas holdup and superficial gas velocity has affirmative gradient effect with gas holdup.

Generally, according to numerous researchers, **Koide, et al., 1984, De Swart,** and **Krishna, 1995**, **Krishna, et al., 1997**, the increase of gas holdups obtained at high gas velocities can be attributed to the higher rate of bubble break-up caused by interaction of turbulent eddies with bubbles. The presence of solid particles can cause a dampening effect on bubble break-up rate due to higher suspension viscosity where the probe response does not increase substantially above a particular velocity which is specified by, **Xue, 2004,** up to 0.35m/s. So, the optical probe response recorded in this study for different superficial gas velocities along with various solid concentration match with the behavior of gas holdup which was proved by the previously mentioned researches.

4. CONCLUSIONS

The effect of low H/D ratios on gas holdup measured by optical fiber probe in large scale slurry bubble column was studied by analyzing the experimental results under operating condition of solid loading and superficial gas velocity. It was found that operating under low H/D ratios gave reasonable values of gas holdup and there is significant variation along the axial direction. As well as, the four tips optical fiber probe which was used in this investigation was able to get reasonable data within good agreement with open literatures. where, the data which have been obtained for gas holdup led to the following finding:

1- At H/D ratio as 3 under different operating conditions, the local gas holdup increased with axial direction and superficial gas velocity become more identical. While, it decreased with elevation of slurry concentration. At the highest solid loading, almost about 20% the trend approached steady state along the height, but with less addition of solid the gas holdup it increased progressively throughout the axial distance.

2- At H/D ratio as 4 with same operating conditions as previous ratio, the gas holdups obtained significantly varied along the column at all solid loadings and there was no identical values along the height with an obvious increasing of gas holdup in comparison with the 3 H/D ratio.

3- At H/D ratio as 5 under the previously mentioned operating conditions, the gas holdup increased along with axial height and approached the value of 0.34 and 0.25 at 9% and 20% loading of solid respectively. This increment started with low value in the region near the distributor and proceed toward the highest value where it approached steady state at this point. The increase of gas flow rate enhanced the gas holdup as expected and had an advantage of approaching steady state early.

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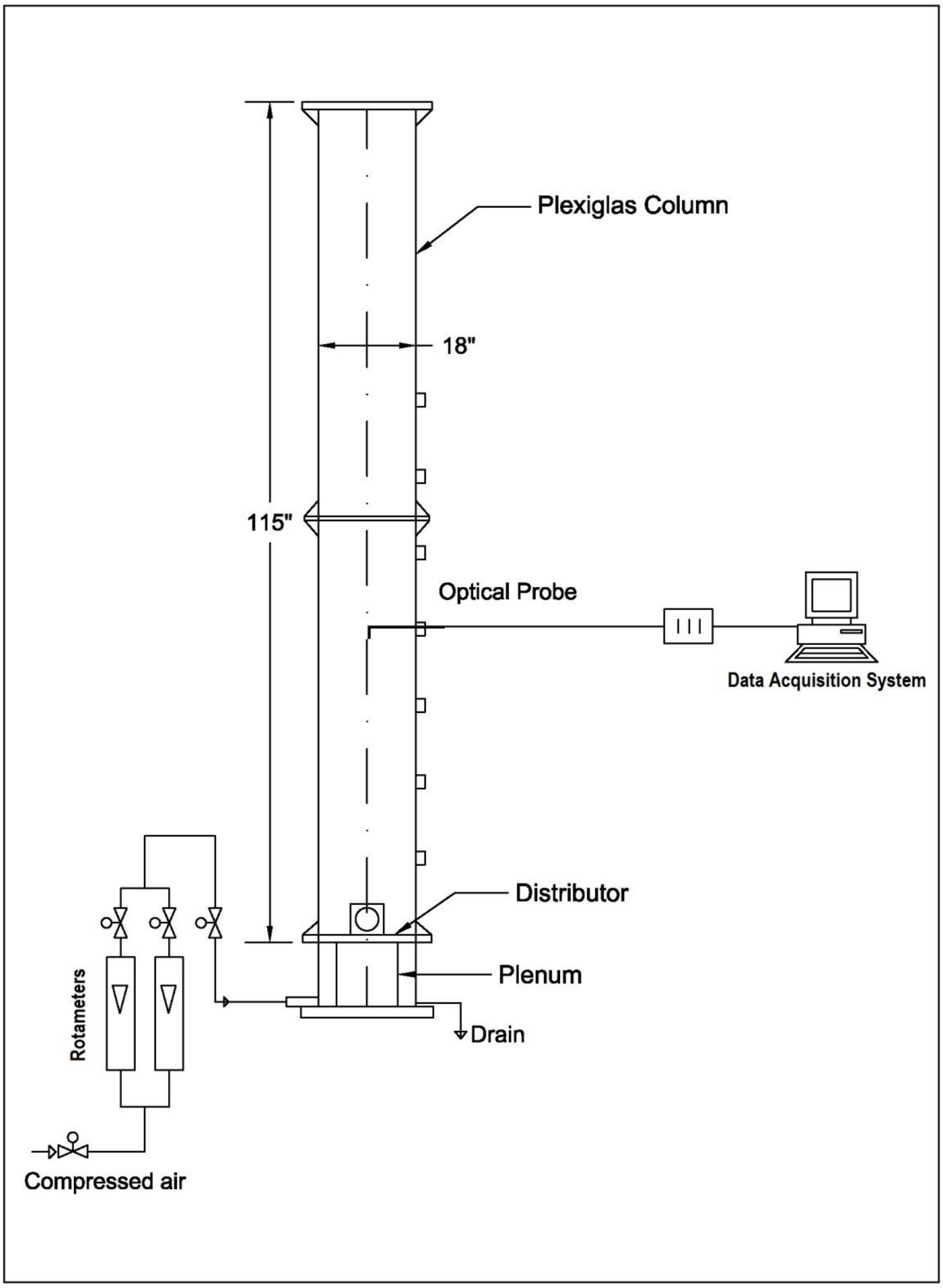
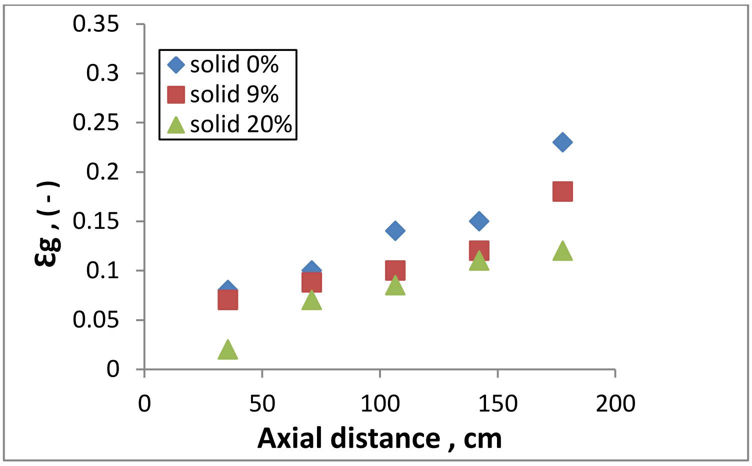
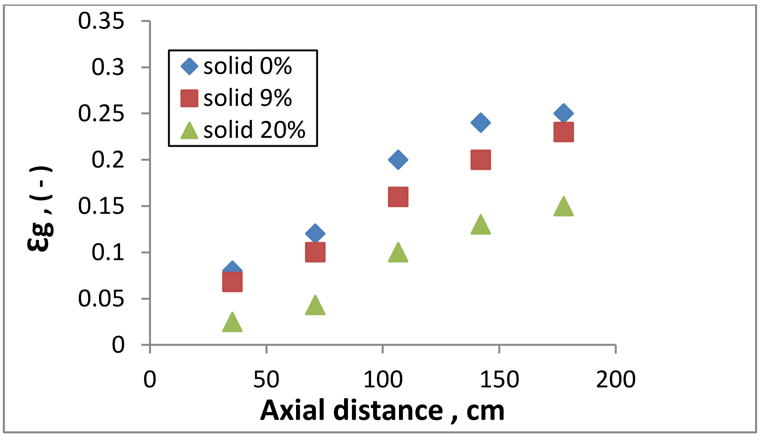


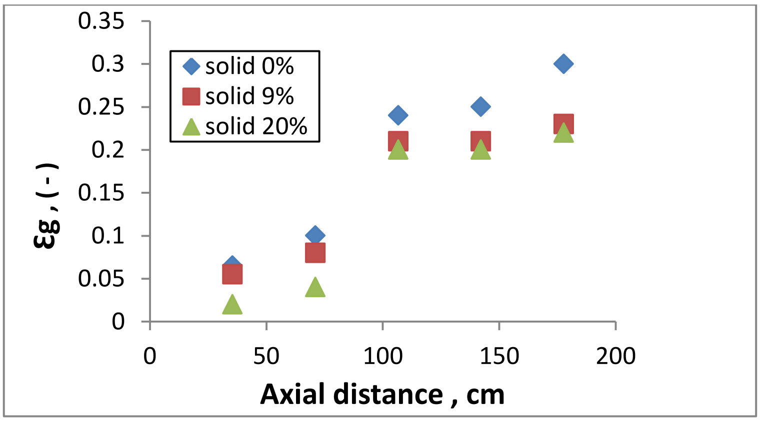
Figure 1. Schematic diagram of the experimental setup.



(a) H/D = 3



(b) H/D = 4



(c) H/D = 5

Figure 2. Variation of local gas holdup with axial distance for different solid concentrations and H/D ratios (a) H/D=3, (b) H/D=4, (c) H/D=5; at Ug=0.08 m/s.

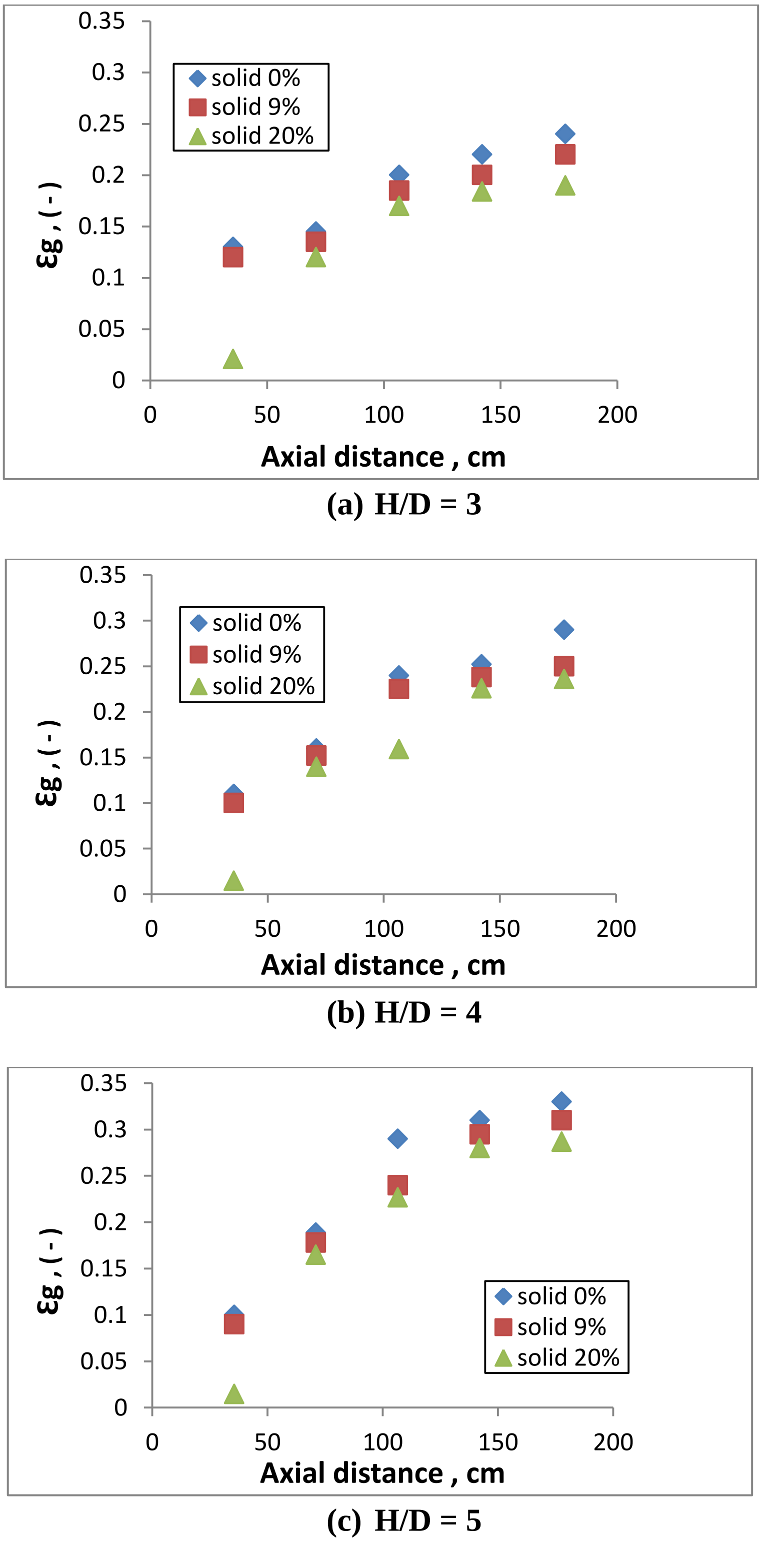
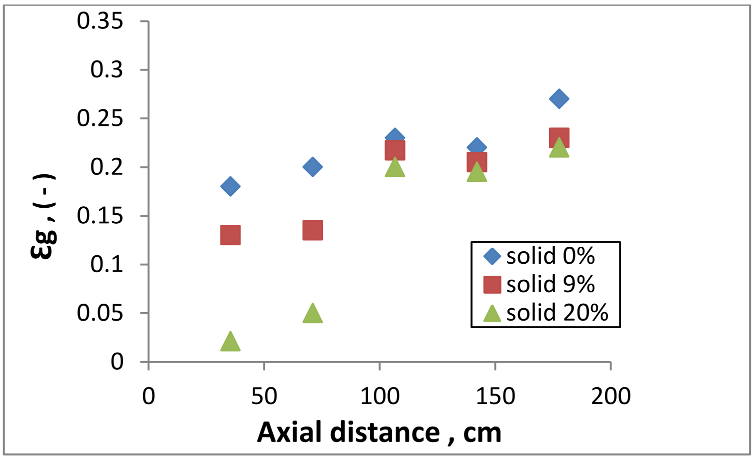
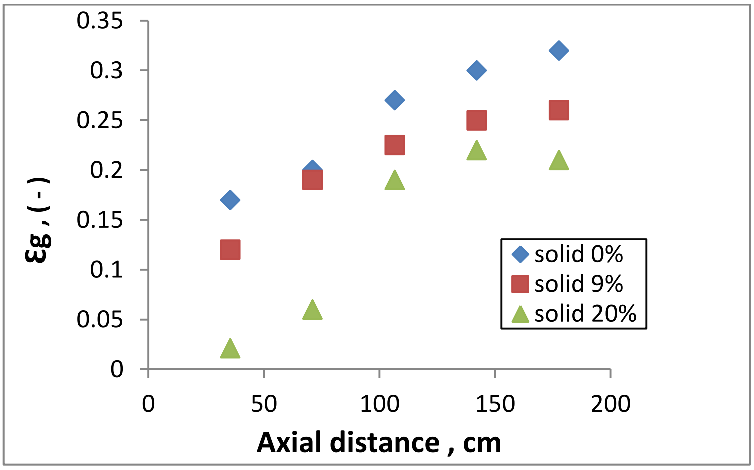


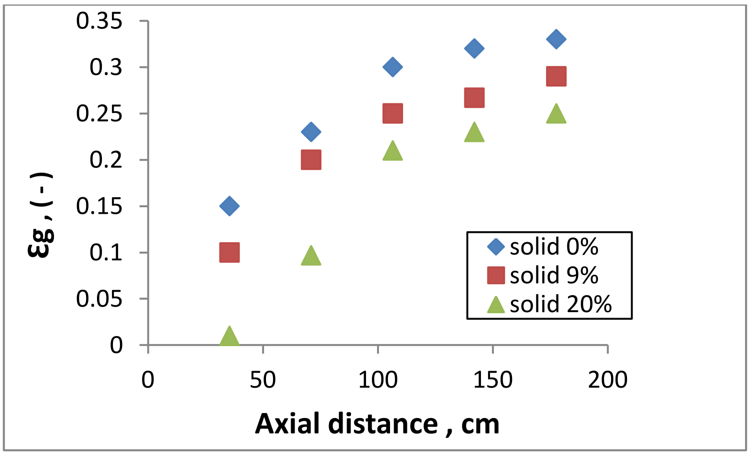
Figure 3. Variation of local gas holdup with axial distance for different solid concentrations and H/D ratios (a) H/D=3, (b) H/D=4, (c) H/D=5; at Ug=0.16 m/s.



(a) H/D = 3

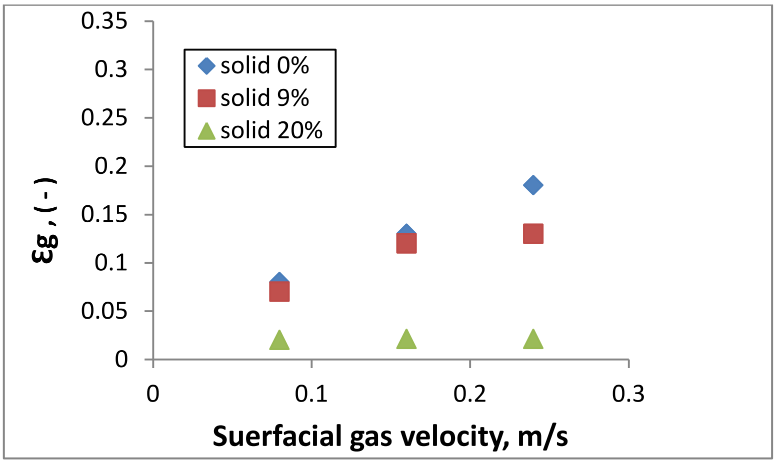


(b) H/D = 4



(c) H/D = 5

Figure 4. Variation of local gas holdup with axial distance for different solid concentrations and H/D ratios (a) H/D=3, (b) H/D=4, (c) H/D=5; at Ug=0.24 m/s.



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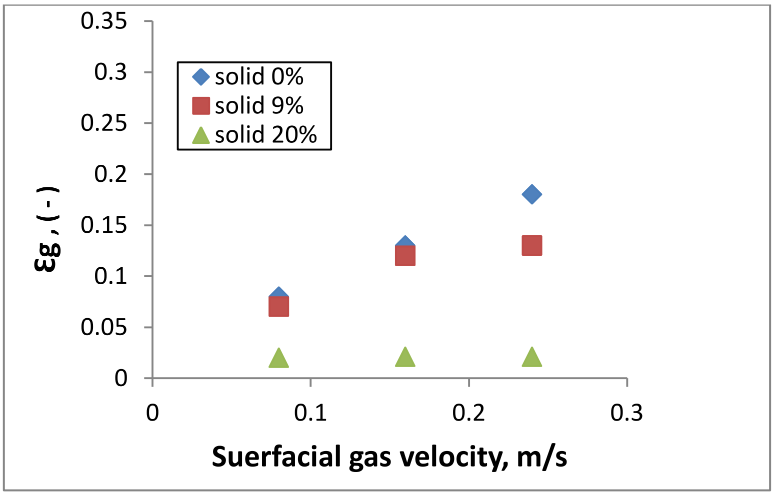

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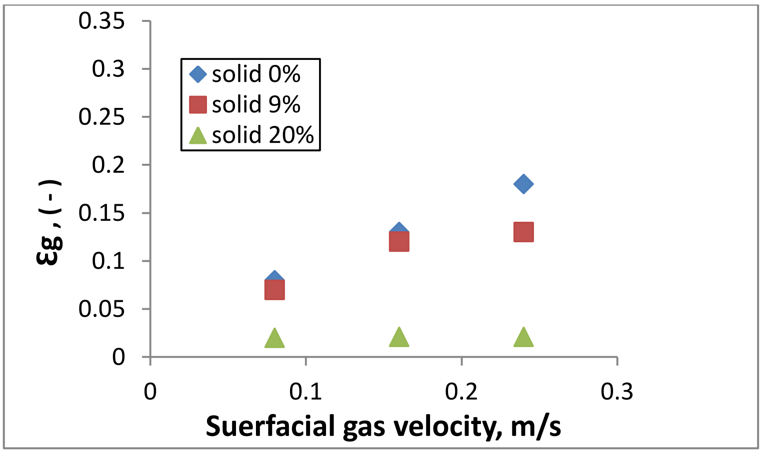
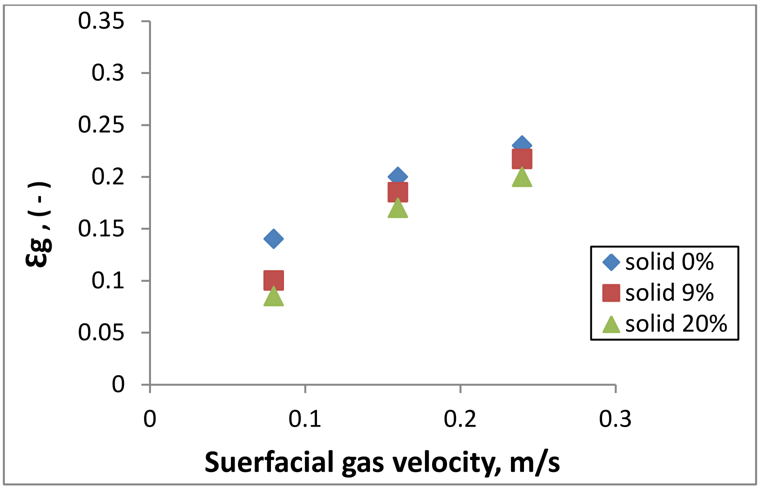


(c) H/D = 5

Figure 5. Variation of axial gas holdup with superficial gas velocity for different solid concentrations and H/D ratios (a) H/D=3, (b) H/D=4, (c) H/D=5; near the distributor.



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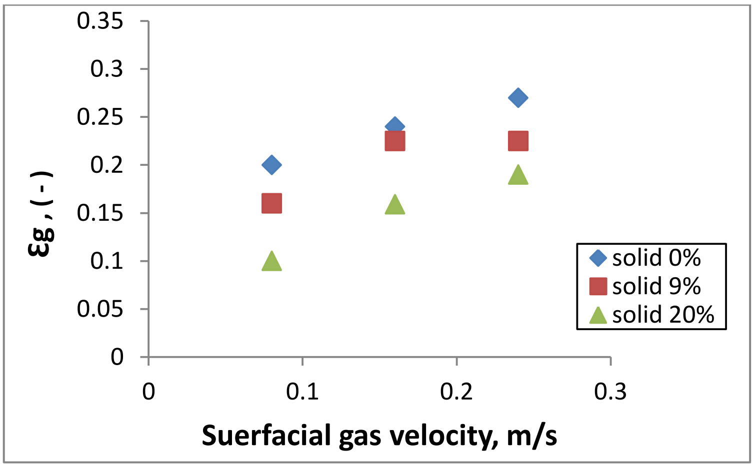

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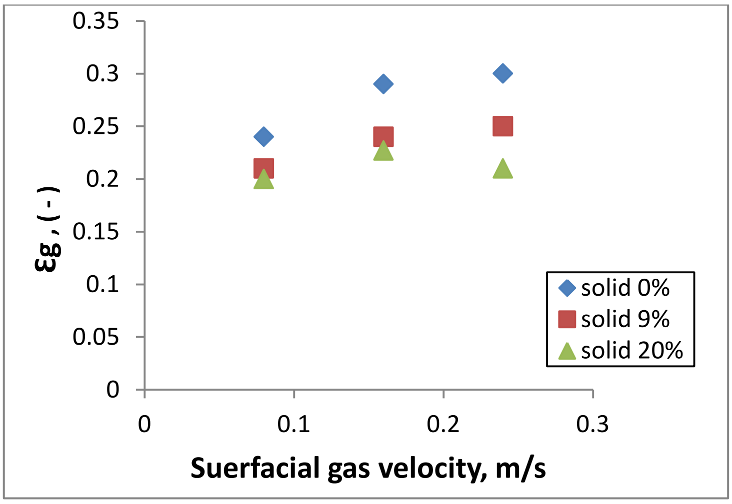
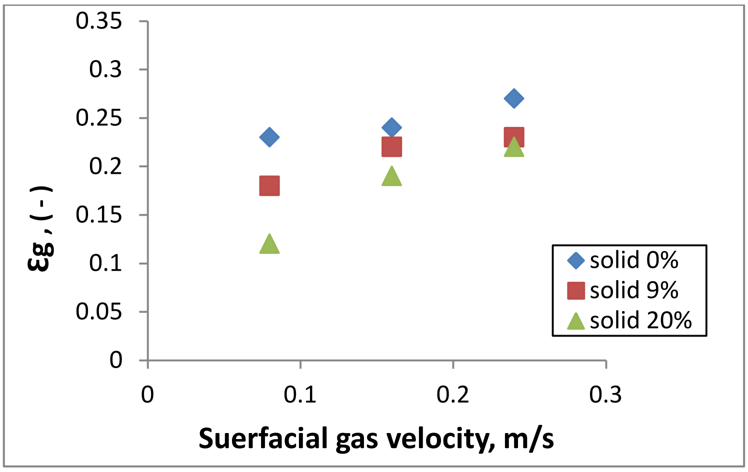


(c) H/D = 5

Figure 6. Variation of axial gas holdup with superficial gas velocity for different solid concentrations and H/D ratios (a) H/D=3, (b) H/D=4, (c) H/D=5; bulk region.



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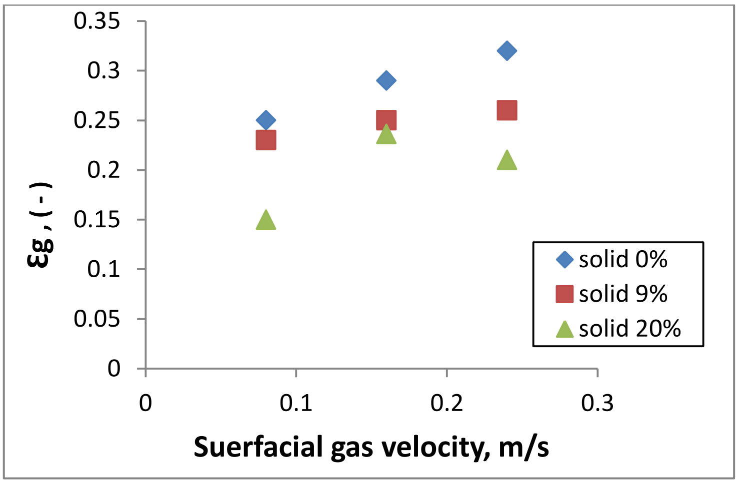

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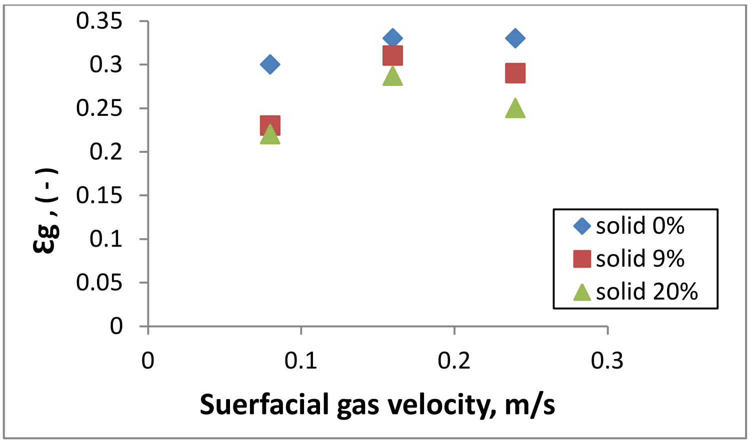

(c) H/D = 5

Figure 7. Variation of axial gas holdup with superficial gas velocity for different solid concentrations and H/D ratios (a) H/D=3, (b) H/D=4, (c) H/D=5; top region.

Dust Effect on the Efficiency of Silicon Mono Crystalline Solar Modules at Different Tilt Angles at Al-Jadryia Climate Conditions

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ABSTRACT

Solar energy usage in Iraq is facing many issues; one of those is the accumulation of the dust on the surface of the solar module which would highly lower its efficiency. The present work study the effect of dust accumulation on installing fixed solar modules with different inclined angles 15^o, 33^o, 45^o, 60^o. Evaluation of the solar modules performance under different circumstance conditions such as rain, wind and humidity are considered in study of dust effect on solar module performance. The results show that the lowest output average efficiencies of solar modules occurs at 15^o horizontally inclined angle are 7.4% , 6.7% , 8.0% , 8.1%, and 8.4% for the corresponding months; June, July, August, October, and September respectively while the highest average efficiencies are 8.9% , 9.1% , 9.4% , 9.6% , 9.6% for an inclined angle 60^o for the same month. lose power output rate for angle 15^o horizontally inclined solar modules are as following 32.6%, 32%,31.6%,34.9%,26.2% for months; June, July, August, October, and September respectively , while the results for the 60^o horizontally inclined solar module are 26.9%, 17%, 24.2%, 28.1%, and 9.7% for the same five months. As a final result is that the 15^o horizontally inclined solar panel is less efficient compared with the 60^o horizontally inclined solar panel and the difference in the results in the months was mainly due to the weather changes (summer and winter). The solar modules efficiency and lose power rate values for the inclination angles 33^o and 45^o are ranged between the values of 15^{o}and 60^o inclination angles.

Keywords: dust, solar module, humidity, wind, and efficiency.

تأثير الغبار على كفاءة وحدات الالواح الشمسية احادية التبلور وبزوايا ميل مختلفة وضمن الظروف المناخية لمدينة الجادرية

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الخلاصة

أن تطبيقات الطاقة الشمسية في العراق تواجه مشاكل كثيرة, واحدة من أهم هذه المشاكل هي تراكم الغبار على سطح الألواح الشمسية التي تسبب انخفاض أدائها بشكل حاد. في العمل الحالي.تم دراسة تأثير تراكم الغبار على كفاءة الخلية الشمسية من خلال نصب ألواح شمسية ثابتة بزوايا ميل مختلفة 15^o,33^o, 45^o,60^o مع الأفق تمت القياسات خارج المختبر. تم تقييم أداء الألواح الشمسية تحت الظروف الجوية مثل هطول الإمطار, العواصف الترابية, الرياح, والرطوبة.تشير النتائج التجريبية إلى أن معدل الكفاءة الخارجة للوح الشمسي المائل بزاوية15^{o}مع الأفق تصل إلى حوالي ,8% ,7.6% ,7.4% ,

8.1%8.4%لأشهر حزيران, تموز,أب, أيلول,تشرين الأول على التوالي. بينما تصل لحوالي 9.4% ,9.1% ,8.9% , 9.6%,9.6% لنفس الأشهر المذكورة سابقا للوح الشمسي المائل بزاوية 60° مع الأفق. وكنتيجة نهائية فان أقصى قيمة لخسائر القدرة الخارجة للوح الشمسي المائل بزاوية 15° وصلت لحوالي 31.6% 32% ,32.6%, ,, 34.9% , 26.2 لأشهر حزيران , تموز, آب, أيلول و تشرين الأول على التوالي. بينما وصلت لحوالي 28.1%9.7% ,24.2% ,17% 26.9% لنفس الأشهر المذكورة سابقا للوح الشمسي المائل بزاوية 60°. من هذه النتائج يمكن ملاحظة إن اللوح المثبت بزاوية 15° مع الأفق اقل فعالية مقارنة مع اللوح الشمسي المثبت بزاوية 60 مع الأفق وان تغير النتائج للأشهر المختلفة (الصيف و الشتاء) هو نتيجة التأثر بصورة كبيرة بالظروف الجوية. كفاءة الالواح الشمسية والتي زوايا ميلها 33° و45° وخسارة القدرة محصورة بين قيم النتائج للزاويتيين 15° و60°.

كلمات رئيسية: الغبار ، اللوح الشمسي، الرطوبة، الرياح، الكفاءة.

1. INTRODUCTION

Most renewable energy sources come from external sources to the earth, primarily from the sun. The most important point is that renewable sources do not run out, in contrast to conventional energy sources based on fossil fuel such as carbon, petrol and gas. The amount of solar energy reaching the earth every year is roughly 10^{24} J. This is more than a thousand times the annual energy consumption of the entire world, indicating that (in principle) the worldwide requirement for energy could be supplied by solar energy. This energy is capable of producing large quantities of electricity for present as well as for future uses, **Delfina, 2008.** Iraq has a good value of solar insolation and the maximum value of insolation distributed in the mid and south of it, as well as, the average annual insolation of Baghdad is equal to about 5.27 kwh/m^2/day. This value is supported by the solar insolation data from NASA research center. Over years, many researchers have studied the characteristics of PV modules and the factors that affect them. **Walker, 2001** has proposed a MATLAB-based model of a PV module to simulate its characteristics and to study the effect of temperature, insolation, and load variation on the available power . The mono and poly crystalline modules output are greatly dependent on the solar radiation perpendicular to the modules, whereas the amorphous panel works even with the diffused radiation. Though the efficiency of the amorphous panels is less but their energy yield is high compared to the others in some cases. Moreover the output of crystalline modules suffers more from dust accumulation as compared to the amorphous modules.

Qasem et al., **2012,** exposed the south-facing glass samples at different tilt angles under outdoor environment conditions for one month in Kuwait. A non-uniformity index defined as transmittance values at the top, middle, and bottom of the samples. Non-uniformity of the vertical sample was found to be 0.21%, while the sample tilted at 30° showed 4.39% non-uniformity between the three sections . This observation suggests non-uniform dust deposition as a function of tilt angle .

Lorenzo et al., 2013, investigated the impact of non-uniform dust deposition pattern on PV arrays in a 2 MW PV park in south-eastern Spain. It has been observed that dusty modules have significantly lower operation voltage than the less dusty or clean ones in the same string. Partially-shaded cells act as loads to clear cells connected in series. Consequently, more output power losses occur in the formation of hot spots. Infrared (IR) images taken from the array showed that hot spots formed in areas with higher dust concentration with up to 23° C higher compared to that of the surrounding panel surface . In long-term exposure, these hot spots cause the thermal degradation of the PV arrays.

The objective of the present work is to study the effect of dust on the efficiency and the efficiency loss of silicon mono crystalline solar modules at different tilt angles at Al-Jadryia climate conditions.

2. DUST EFFECT ON THE PV SOLAR PANEL

Soiling is a term used to describe the accumulation of dirt on solar panels that reduces the amount of sunlight reaching solar cells. Also Soiling includes not only dust accumulation, but also surface contamination by plant products, soot, salt, bird droppings, and growth of organic species, adversely affecting the optical properties. “Major performance-limiting factors other than soiling include temperature effects (primarily in mono-crystalline silicon and multi-crystalline silicon PV modules), high relative humidity (RH), high wind speed, corrosion, and delimitation of the energy conversion devices”. It is often a problem in the areas where it is not raining for months in a row. This has a cascading effect on performance, from the reduction of sunlight to causing reduced energy absorption by solar cells. This can cause the whole system to work harder and consequently reduces energy output, **Al-Hasan, 1998.** While dust is term generally applying to minute solid particles with diameters less than 500 μm. It occurs within the atmosphere from various sources such as dust lifted up by wind, pedestrian and vehicular movement, volcanic eruptions, and pollution. Dust would also refer to the minute pollens (fungi, bacteria and vegetation) and micro fibers (from fabrics such as clothes, carpets, linen, etc.) that are omnipresent and easily scattered through the atmosphere and consequently, settle as dust**, Mani and Pillai, 2010**. Studying the dust effect on the PV panel will help to select panel technology for a particular type of application and location. The accumulation of dust particles on the surface of PV module greatly affects its output power, especially in the desert areas. However, desert countries are suited for photovoltaic power generation due to abundant availability of sunlight throughout the year. Experiments have shown that just 2 mg/cm^{2}of fine dust on solar panel can reduce its output by nearly 30%. At 8 mg/cm^2 dust deposition, output is reduced to just 10% of that obtainable for a clean panel, **Horenstein et al., 2011.** In bigger PV solar panels, more work forces and machines will be needed to keep making the rounds and cleaning the panels, especially after a sand storm **CSEM, 2010.**The dust accumulation on the PV panel surface depends on different parameters like PV panel inclination, kind of installation (stand alone or on tracker), humidity, etc.

3. OUTPUT CHARACTERISTICS OF SOLAR MODULES

The output characteristics of solar cells are expressed in the form current-voltage curve. A test circuit and typical current-voltage curve produced are shown in **Fig.1**. The current-voltage curve is produced by varying R_L (load resistance) from zero to infinity and measure the current and voltage along the way. The point at which the current-voltage curve and resistance (R_L) intersect is the operating point of the solar cell. The current and voltage at this point are I_p and V_p, respectively. The largest operating point in the square area is the maximum output of the solar cell as it's demonstrated in **Fig.2**. Fill factor (FF) is the relation between the maximum power that the panel can actually provide and the product I_{SC} .V_{OC}. This gives you an idea of the quality of the panel because it is an indication of the type of I-V characteristic curve. The closer FF is to 1, the more power a panel can provide. Common values usually are between 0.7 to 0.8. Solar module efficiency (η) is the ratio between the maximum electrical power that the module can give to the load and the power of the solar radiation (P_L) incident on the module. This is normally around 10-12%, depending on the type of cells (mono-crystalline, polycrystalline, amorphous or thin film). Considering the definitions of point of peak power and the fill factor as its follows:

$$\eta = \frac{P_{max}}{P_L} = FF\ \frac{I_{sc}V_{oc}}{P_L} \quad (1)$$

$$FF = \frac{I_{mp}V_{mp}}{I_{sc}V_{oc}} \quad (2)$$

4. EXPERIMENTAL MEASUREMENTS

4.1 Description of the System

Four different tilt angles were chosen for the fixed system of four monocrystalline solar module (solar module specification are available in **Table 1**). The first angle was (15^o) with the horizon as it is assumed to be the appropriate angle for summer application because the average of solar zenith angle is about (15^o), in addition to that Iraq suffers from an increase of solar radiation in Summer. The second angle was (33^o) with the horizon as it is assumed to be the appropriate angle in Baghdad for the annual applications to get a good match with latitude of Baghdad (33^o), according to the information data of NASA (NASA 2002) and other research results, **Al-Sudany 2009.** The third and fourth angles are 45^o and 60^o respectively with the horizon as it is assumed to be the appropriate angle for winter applications because the average of solar zenith angle is about 45^o and 60^o, in addition to that Iraq suffers from a decrease of solar radiation in Winter due to optical path of radiation (air mass) compared with that in Summer season. Four similar solar panels with power of 50 watt (dimensions; length, width, and thickness =845x545x35mm) are fixed at previous angels.

All of the modules are calibrated according to standard procedure supplied by the manufacturer and to be cleaned at the beginning of every month (June, July, August, September, and October) to study effect of accumulated dust for each month. The solar modules system is available in **Fig.3**.

Solar module analyzer (prova 200) is used for testing and maintenance of solar panels and modules (see **Fig.4**). **Table 2** provides the general specification of prova 200. **Table 2** provides the accuracy and solution of the solar module analyzer. The prova 200 solar panel analyzer can be used in the manufacturing and testing the solar panels and cells. The portability of this device is useful in quality assurance at various stages on the production line and can be taken from one location to another .

Data Logging Solar Power Meter TES-1333R is used for measuring solar radiation flux (W/m^2) (see **Fig.5**). Besides dealing with high power (up to 2000W/m^2 / 634Btu) it also handles a range of spectrum, from UV (400nm) to IR (1000nm).The sensor is a photovoltaic sensor, which ensures stable and good measurements over a long time. The instrument is also Cosine-corrected for the angular incidence of solar radiation. Also that TES-1333R has four digit displays with 0.1W/m^2/0.1Btu resolution.

Prova 200 and TES-1333R are calibrated according standard procedure supplied by the manufacture using on-line software programs.

5. RESULTS AND DISCUSSION

Present work was performed to evaluate the performance of PV solar module under the effect of natural dust deposition on the fixed solar panel with different tilt angles and fix solar radiation 1000 W/m^2 (to get this values at outdoor condition, depending on time and tilt angle of the module; for example module with tilt angle 15^o will be have a solar radiation 1000 W/m^2 at 11.00 a.m.). The exponential work have made during the five months from June to October 2014. This work is done at an average temperature of 40^oC and average wind speed 2 km/hr. **Figs.6** and **7** show the relation between the efficiency and efficiency drop for Jun month as a function of the deposition period for four tilt angles: 15^o, 33^o, 45^o, and $60°$

respectively. **Fig.8** to **Fig.15** demonstrate the efficiency and efficiency drop for months; July, August, September and October respectively. The perturbations in the curve are due to the effect of weather conditions which occur during the test period such as wind, dust storm, and rainfall .The first day of month represents the start of the work where all the panels were cleaned. In Jun, it can be seen that the value of output power losses reached the maximum value compared with that of the other months July, August, September and October because a heavy dust storm was occurred which caused a deposition of dust on the solar panels surface. It can be seen after eight (8) days for deposition period that the losses were increased with respect to decrease in efficiency as the deposition period continued and then followed by wind storms that lead to natural cleaning and hence to a reduction of losses. With the deposition period continued the losses increased. Consequently, the maximum efficiency losses reached about 32.6% for the tilt angle 15^oin June and the average of losses for this period are about 23.8%.On the other hand, the case of other tilt angles 33^o, 45^o, and 60^o facing the south, the losses in the efficiency of solar modules are less than that of solar module at tilt angle 15^o because the increasing of the tilt angle of the PV solar panel leads to the reduction of the deposited dust on the solar module surface due to the small change of the gravitational force for dust particles and therefore leads to the decrease of losses resulting from the accumulation of dust. From **Fig.8** it can be seen that the maximum losses in June are about 30%, for tilt angle 33^o, 28.4 % for tilt angle 45^o, and 26% for tilt angle 60^o, it can be seen that tilt angle 60^o is much butter compared with the other angles.

In June, although a heavy dust storm was occurred after 13 days of deposition period with average value of relative humidity about 34.3%, but the average efficiency and losses in efficiency were reduced than other months due to the activity of high winds which plays an important role in reduction of accumulated dust on the solar modules surface. In addition to that this month was characterized by high temperatures with average of 46.1^oC and low humidity which leads to decrease the adhesion force for dust particles on the solar modules surface which means for dry months the accumulated dust is low. The weather conditions for this month, play an important role in reducing the accumulation of dust on the solar panels surface; therefore, the maximum efficiency losses reach to 32%, 30.3%, 30 % and 17% for fixed solar panels at tilt angle (15^o, 33^o, 45^o, and 60^o) respectively, whereas the average losses in efficiency for this month reached to 24%, 18%, 15.4% and 8.8% for all four cases. This month is similar in behavior with the dry months (June and July), which is characterized by dust storms occurred for several times , While the maximum losses in efficiency reached to 31.6%, 30.4%, 28.4% and 24.2% for fixed solar panels at tilt angles (15^o, 33^o, 45^o, and 60^o) respectively because the activity of winds which plays an important role in reduction of accumulated dust on the solar panels surface and low humidity which leads to decrease the adhesion force for dust particles on the solar panels surface, Where the average value of humidity for this month of about 25%, whereas the average losses in efficiency for this month reached to 20.3%, 16.6%, 10.46 and 8.6% for all four cases. Finally we can see that the losses in this month are less than previous months.

From these results it can be seen that the average loss in the efficiency of fixed solar panel at tilt angle (60^o) are less than that of solar panel at tilt angle (33^o) for the before mentioned reason. From all results which are previously mentioned, this method is very effective for reducing the accumulation of deposited dust on the solar panel surface dramatically and effectively. This is illustrated in the **Figs.16** and **17** for five months of the year, namely: June, July, August, September, and October .

The percentage efficiency loss of mono-crystalline solar module with tilt angle 33^o is 25% during period date 1 July 2014 to 1 August 2014(at Baghdad/ Al-Jadryia city), while the percentage efficiency loss for the same type of solar module and during period date 1 July 2012 to 1 August 2012 with tilt angle 30^o is 15% (at Kuwait city), **Qasem, 2013**. He also found the long exposure patterns (30 day) led to higher losses in efficiency of 19.4% in comparison to 14.8% for the short exposure (few days). While the present work result for the same approximated conditions is 12% and 20% respectively.

The percentage efficiency loss of mono-crystalline solar module with tilt angle 15^o is 33% during period date 1 September 2014 to 20 September 2014 (at Baghdad/ Al-Jadryia city), while the percentage efficiency loss for the same type of solar module and during period date 1 September 2011 to 30 September 2011 with tilt angle 15^o is 45% (at University of Technology/ Energy center), **Jasim et al., 2015**.

6. DUST PARTICLE SIZE

A sample of dust 0.3gm has been collected from the panel which was instilled at altitude of 10 m. The sample weighted then it has been solvent in 100 mm of water. The sample is put in grain size measurement device (SALD-2101) and by special program; the range of grain size is collected. The result of grain size test is shown in **Fig.18** (the analysis of dust grain size has been made at ministry of science and technology). The graph shows that 10% of the total amount has an average diameter of 0.798μm, 50% of the total amount has an average diameter of 9.146μm, and 75% has an average diameter of 16.800μm. As it clear, the larger amount of dust belongs to the particles which have bigger diameter. Because the bigger grains are heavy, they tend to instill on the surfaces because of the gravity. Whenever the altitude increased, the dust particle becomes lighter and smaller and that is the reason behind this small dust size grain. As it is mentioned before the finer particles become more adhesive and stick to the surface of the solar panel, reduce panel's performance and make the cleaning operation more difficult.

7. CONCLUSION

The results of the experimental work are used for evaluating the performance of PV solar panels under natural deposition of dust in Baghdad environment conditions. The losses in the power of fixed solar panel at tilt angle 60^o with the horizon are less than that of solar panel at tilt angle 15^o with the horizon. The weather conditions affect significantly on the accumulation of dust on solar panels which leads to effect on their performance such as the rain in some months causes natural cleaning for PV solar panels especially during October. The high wind speed plays an important role in natural cleaning which leads to reducing the accumulated dust on the solar panels surface especially in summer months. The accumulated dust on the solar panels surface in summer months is more than that in winter months.

Nomenclature

FF =fill factor, dimensionless.
I_L =photocurrent of the solar cell, A
I_m, I_{mp}, I_{max} =maximum current of solar cell, A
I_{sc} =solar module short- circuit current, A
K =Boltzman’s constant, J/K
L =latitude angle, degree
N =number of aerosol particles.

PV =photovoltaic.
P_L =solar radiation, W/m^2
P_m, P_{mp}, P_{max} =maximum power, W
R_L =load resistance, Ω
V_{mp} =solar module maximum voltage, V
Voc=solar module open-circuit voltage, V
η =solar module efficiency, %

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Table 1. Technical specification of used solar module at standard test conditions (STC)

Rated power	**50 W**
Voltage at maximum power (V_{max})	17.2V
Current at maximum Power (I_{max})	2.9A
Open circuit voltage (V_{oc})	21.8V
Short circuit current (I_{sc})	3.25A
Total number of cells in series	36
Module weight	6 kg

Table 2. Specification of solar module analyser (prova 200).

Battery type		**Rechargeable, 2500mAh(1.2V)*8**
AC Adaptor		AC 110V or 220V input DC 12V / 1~3A output
Dimension		257(L) * 155(W) *57(H) mm
Weight		1160g
Operation environment		0^oC ~ 50^oC,85% RH (relative humidity)
Temperature coefficient		0.1% of full scale/ ^oC (<18^oC or >28^oC)
Storage environment		-20^oC ~ 60^oC ,75% RH
accessories		User manual * 1, AC adaptor*1 Optical USB cable*1 Software CD *1, software manual *1 Kelvin clips(6A max) *1 set
DC voltage measurements		
Range	**Resolution**	**Accuracy**
0-6	0.001V	±1% ±(1% of V_{open}±9 mV)
6-10 V	0.001V	±1% ±(1% of Vopen±0.09 V)
10-60 V	0.01 V	±1% ±(1% of Vopen±0.09 V)
DC current measurements		
Range	**Resolution**	**Accuracy**
0.01-6 A	0.1mA	±1% ±(1% of I_{short}±0.9 mA)
0.6-61A	0.1mA	±1% ±(1% of I_{short}±0.9 mA)
1-6 A	1mA	±1% ±(1% of I_{short}±0.9 mA)

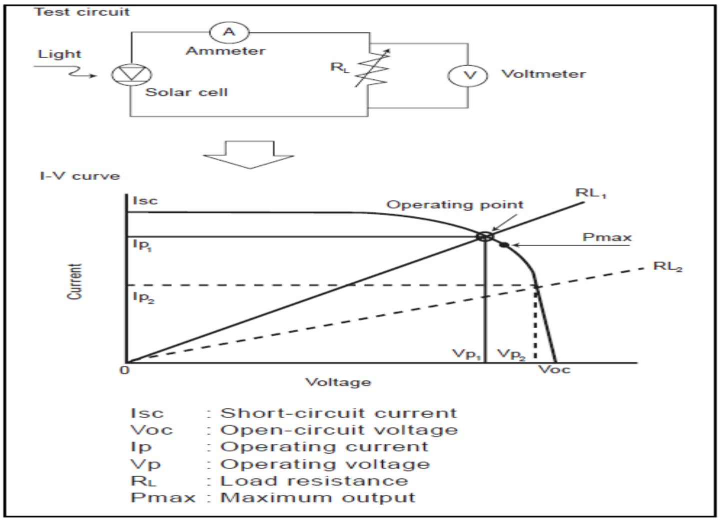


Figure 1. Current-voltage curve is produced by varying RL (load resistance) from zero to infinity, **Gracia et al., 2006.**

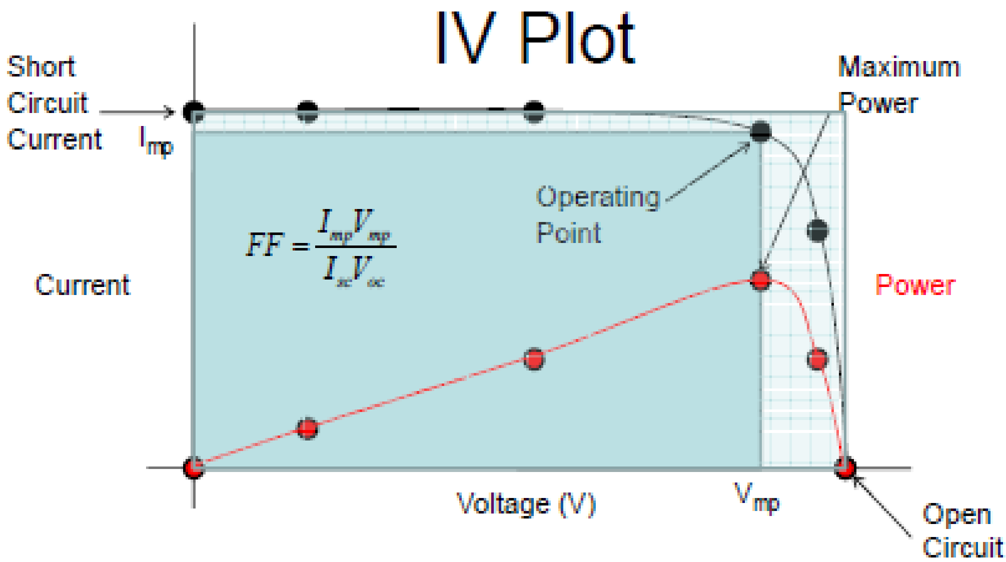


Figure 2. Square area gives maximum power output of the solar module**, Gracia et al., 2006.**

Tilt angle: 60^o 45^o 33^o 60^o

Figure 3. Photograph of the setup of the fixed solar modules system with different tilt angles 15^o ,33^o, 45^o and 60^o.

Figure 4. Prova 200 solar panel analyzer.

Figure 5. Solar power meter.

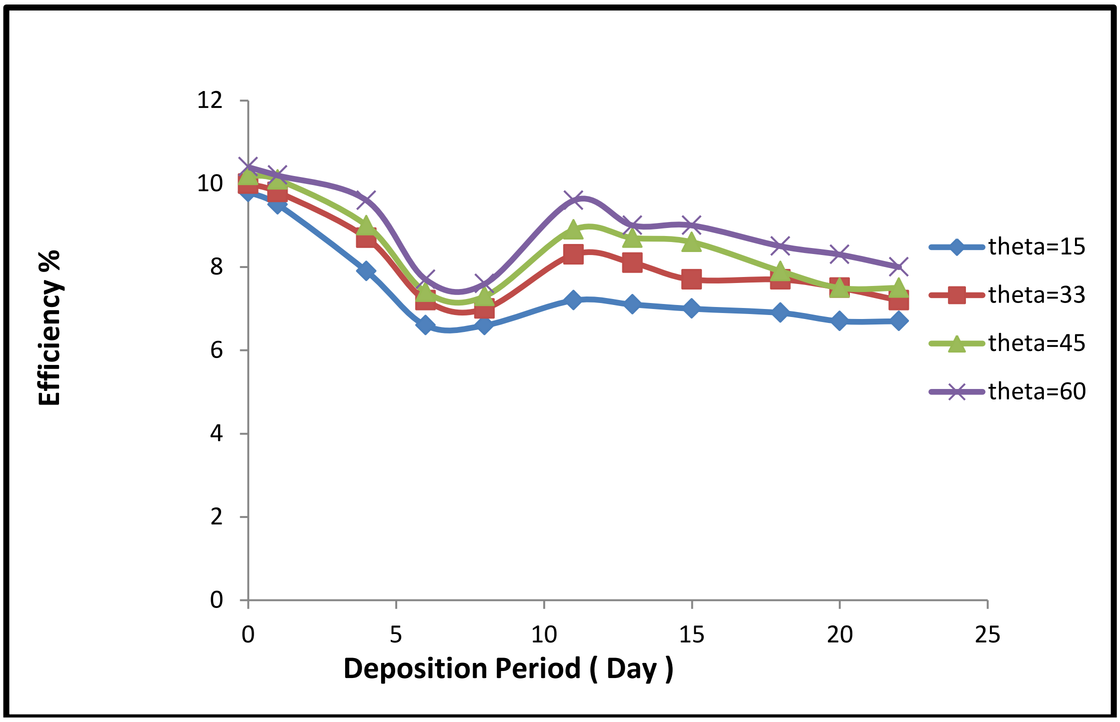


Figure 6. Efficiency versus deposition period for fixed panels at tilt angles (15°, 33°, 45° and 60°) in June.

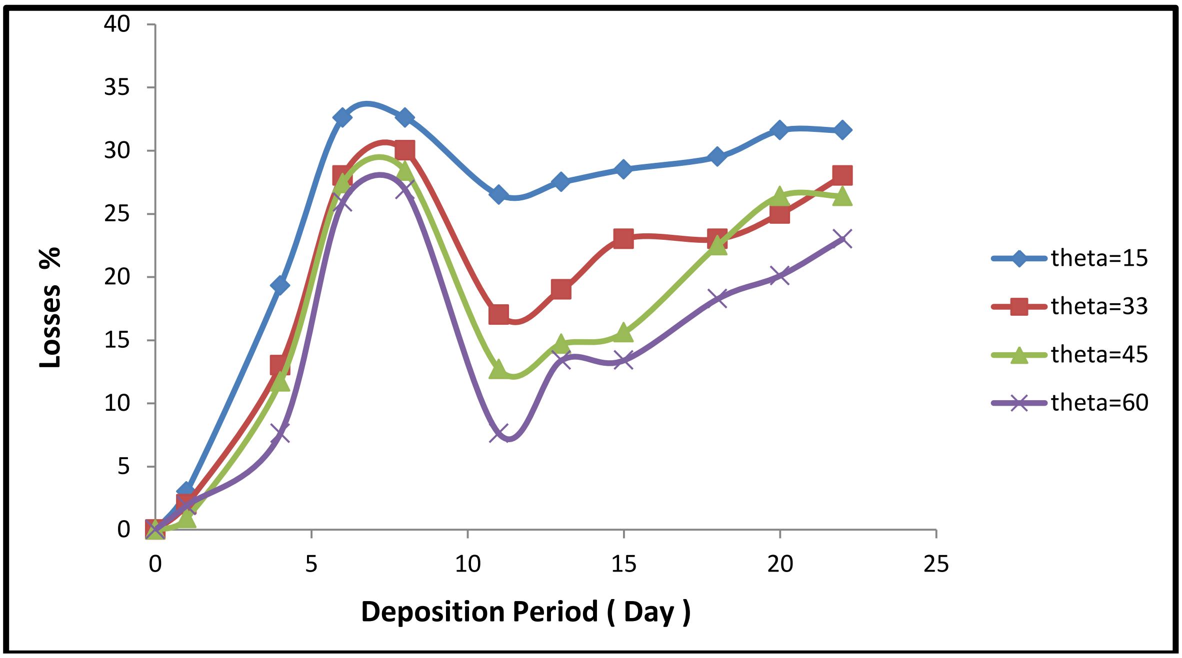


Figure.7 The efficiency losses versus deposition period for fixed panels at tilt angles (15°, 33°, 45° and 60°) in June.

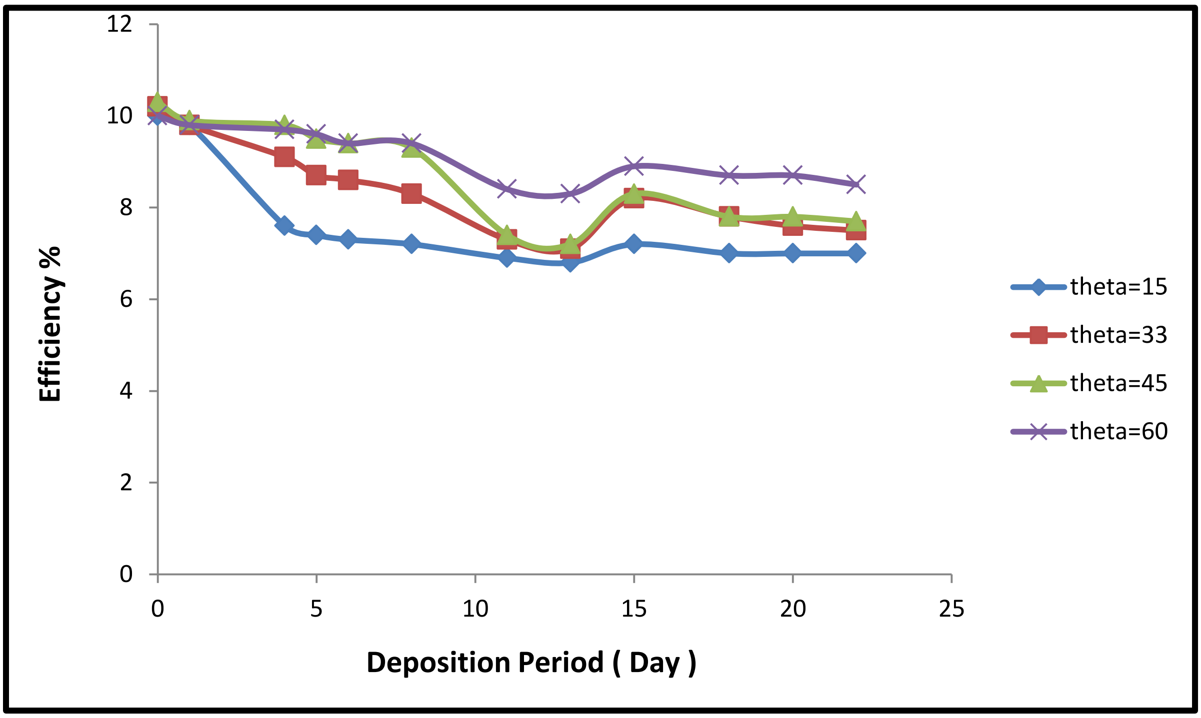


Figure.8 The efficiency versus deposition period for fixed panels at tilt angles (15°, 33°, 45° and 60°) in July.

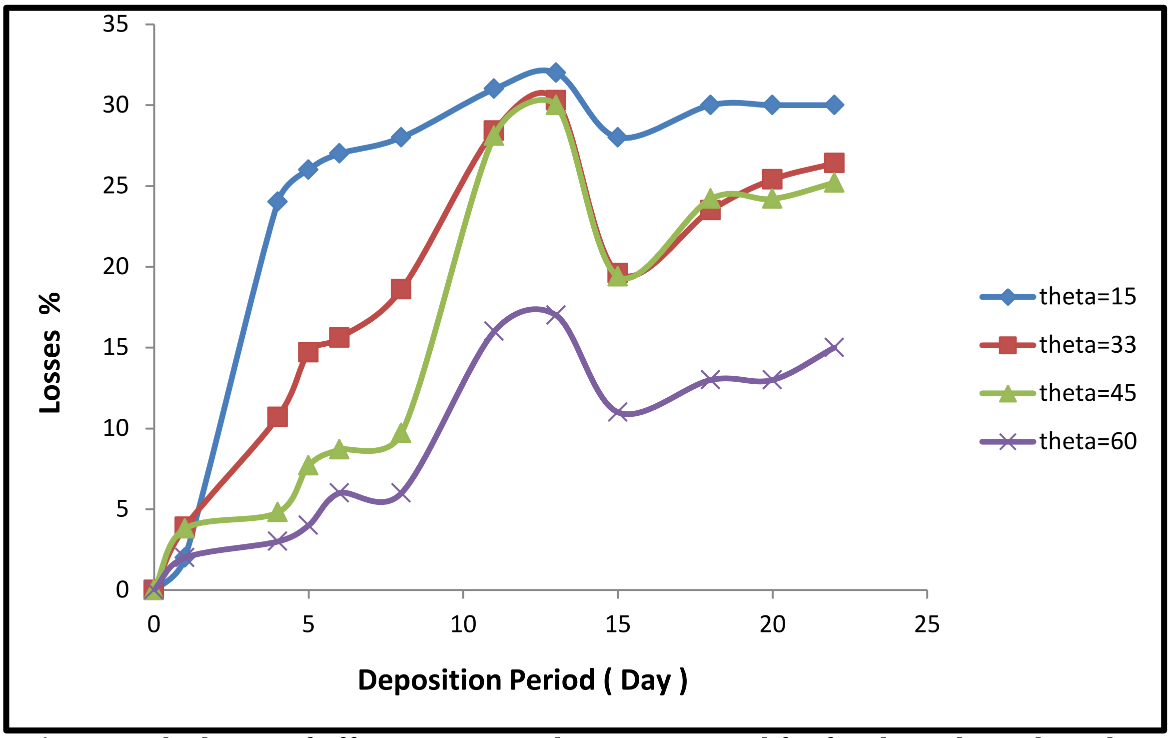


Figure.9 The losses of efficiency versus deposition period for fixed panels at tilt angles (15°, 33°, 45° and 60°) in July.

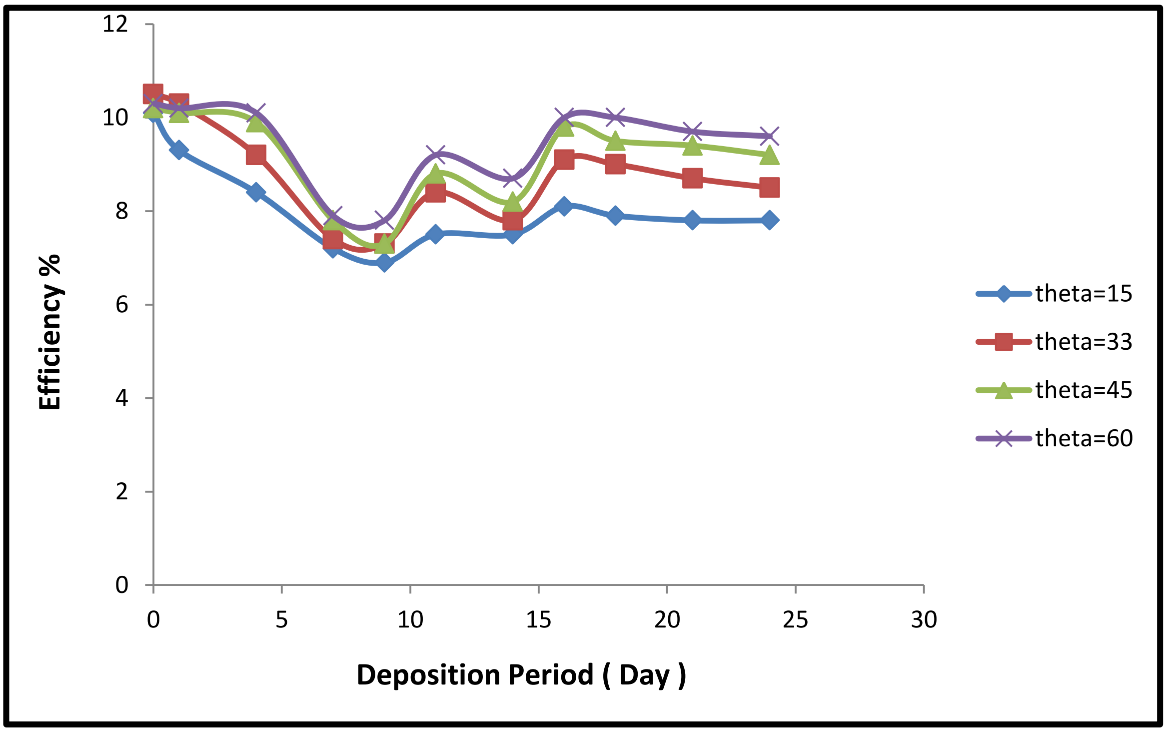


Figure.10 The efficiency versus deposition period for fixed panels at tilt angles (15°, 33°, 45° and 60°) in August.

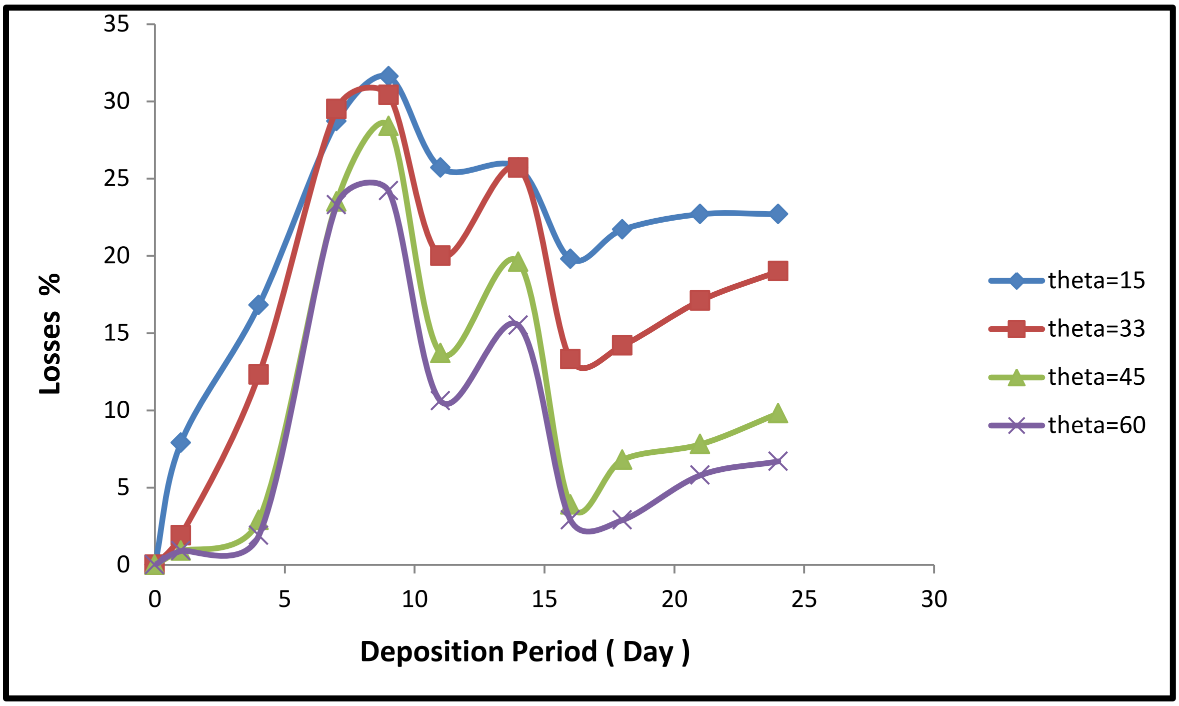


Figure 11. The losses of efficiency versus deposition period for fixed panels at tilt angles (15°, 33°, 45° and 60°) in August.

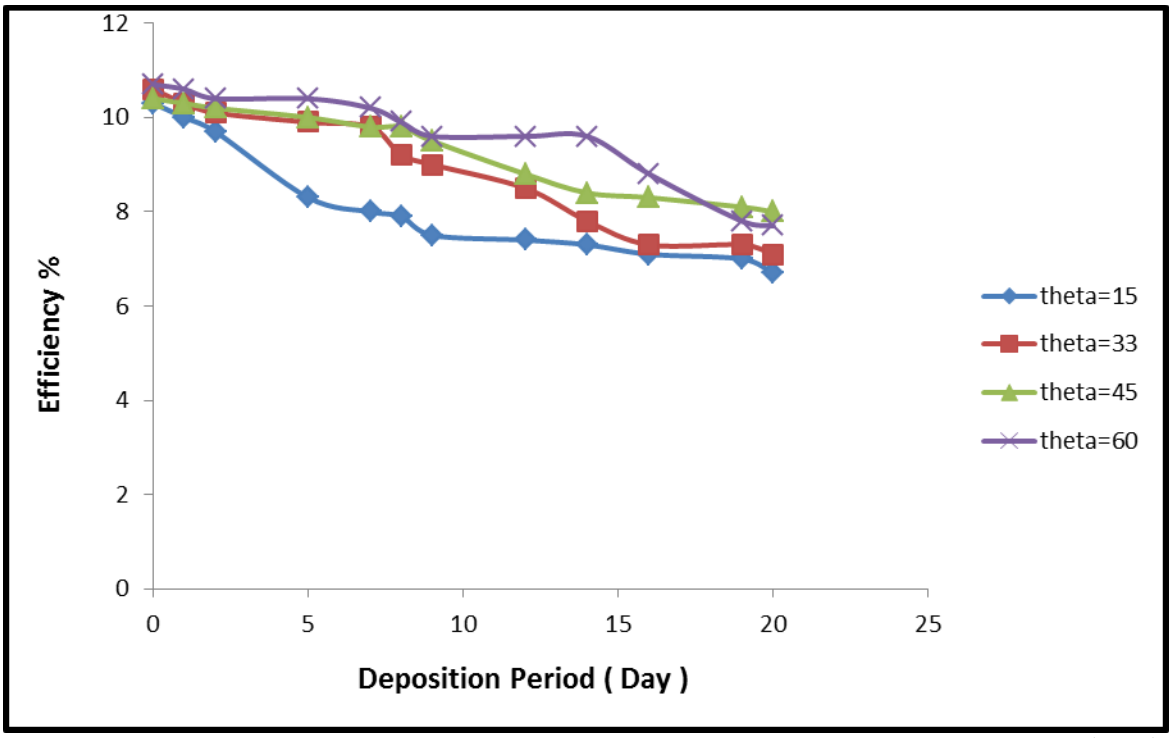


Figure 12. The efficiency versus deposition period for fixed panels at tilt angles (15^o, 30^o, 45^{o}and 60^o) in September.

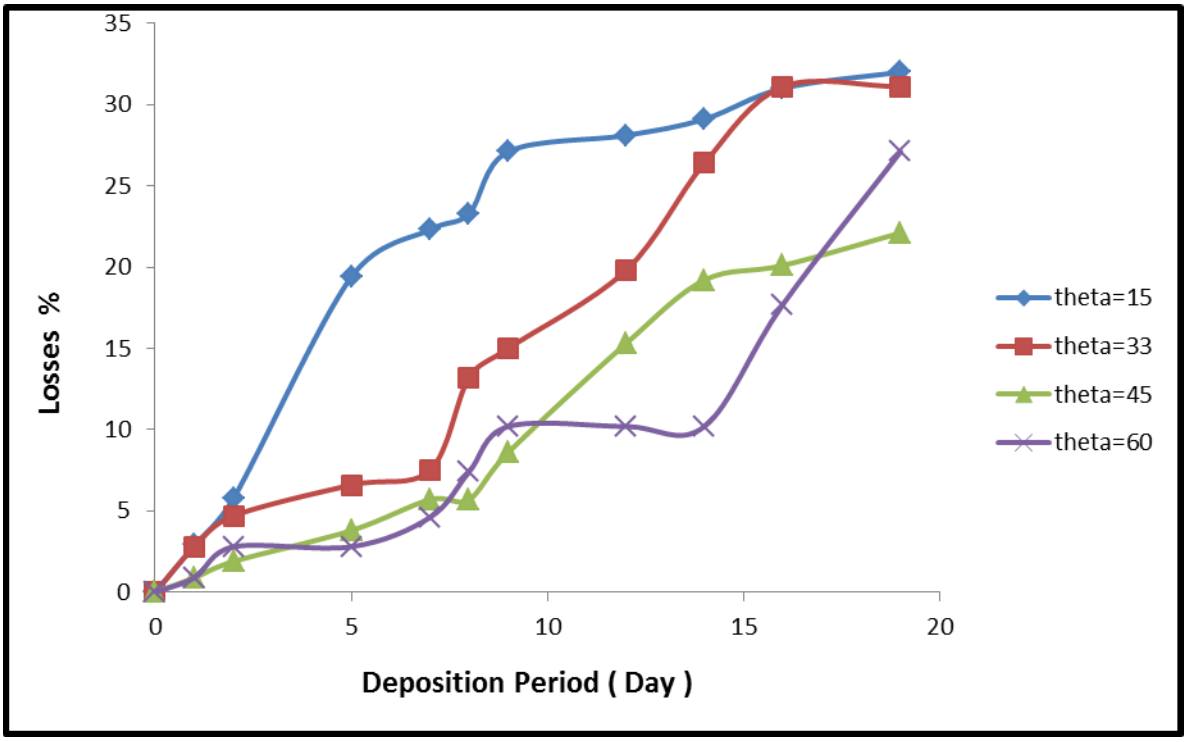


Figure 13. The losses of efficiency versus deposition period for fixed panels at tilt angles (15°, 33°, 45°and 60°) in September.

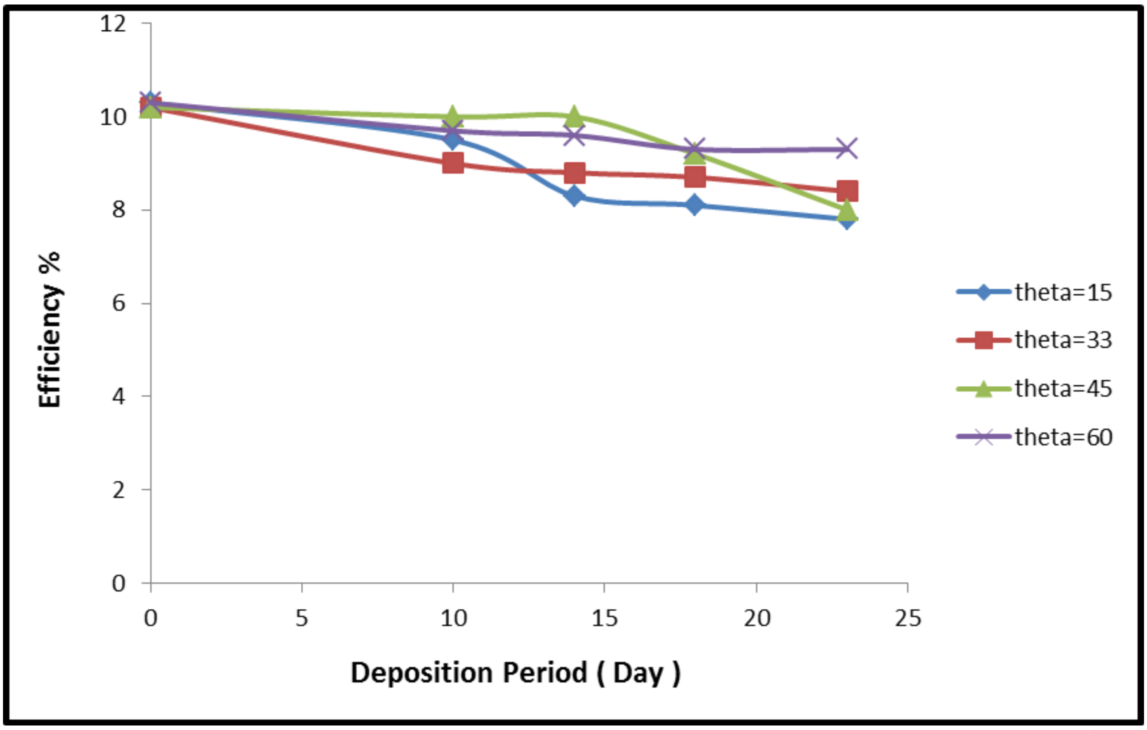


Figure 14. The efficiency versus deposition period for fixed panels at tilt angles (15°, 33°, 45°and 60°) in October.

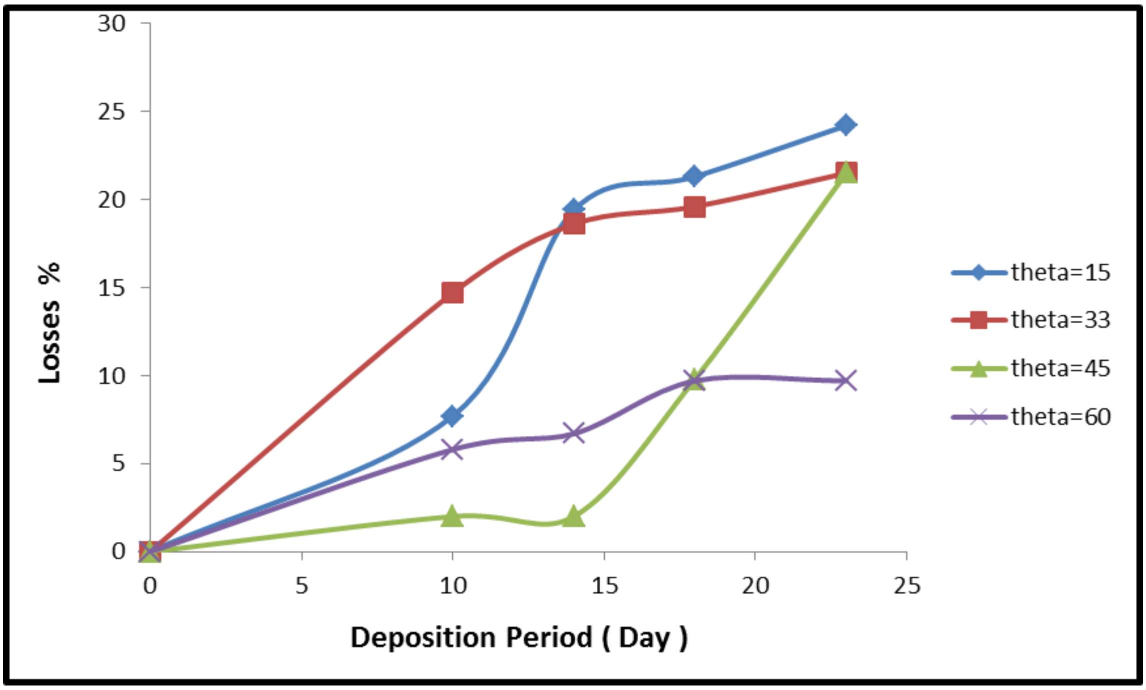


Figure 15. The efficiency losses versus deposition period for fixed panels at tilt angles (15^o, 33^o, 45^{o}and 60^o) in October.

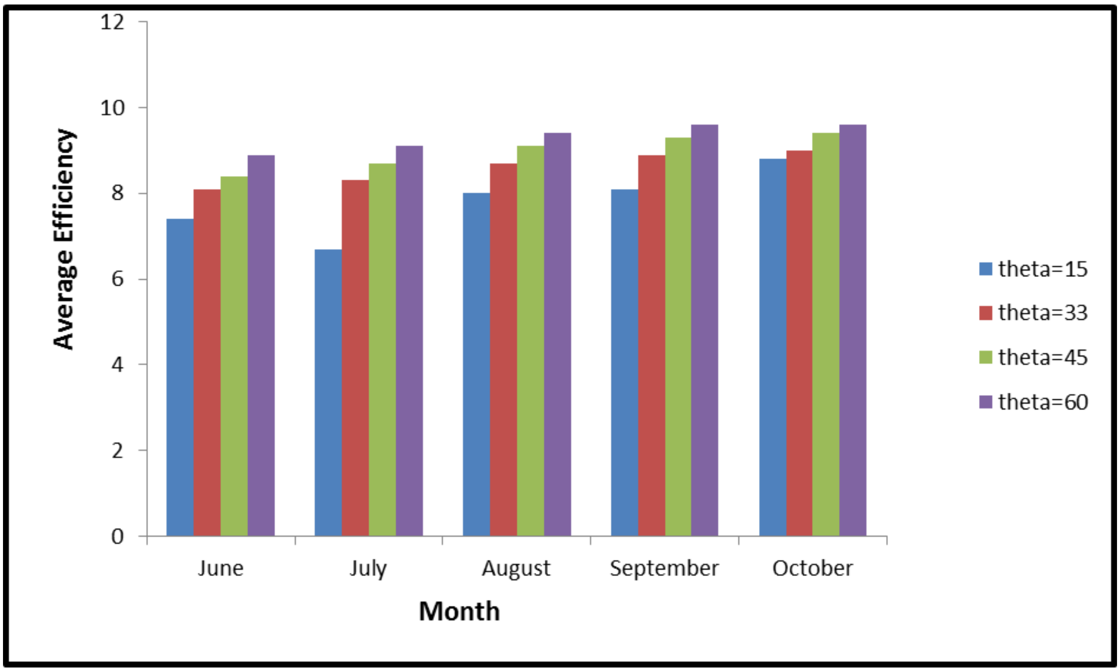


Figure 16. The monthly average efficiency due to dust in Baghdad for fixed panels at tilt angles (15^o, 30^o, 45^{o}and 60^o).

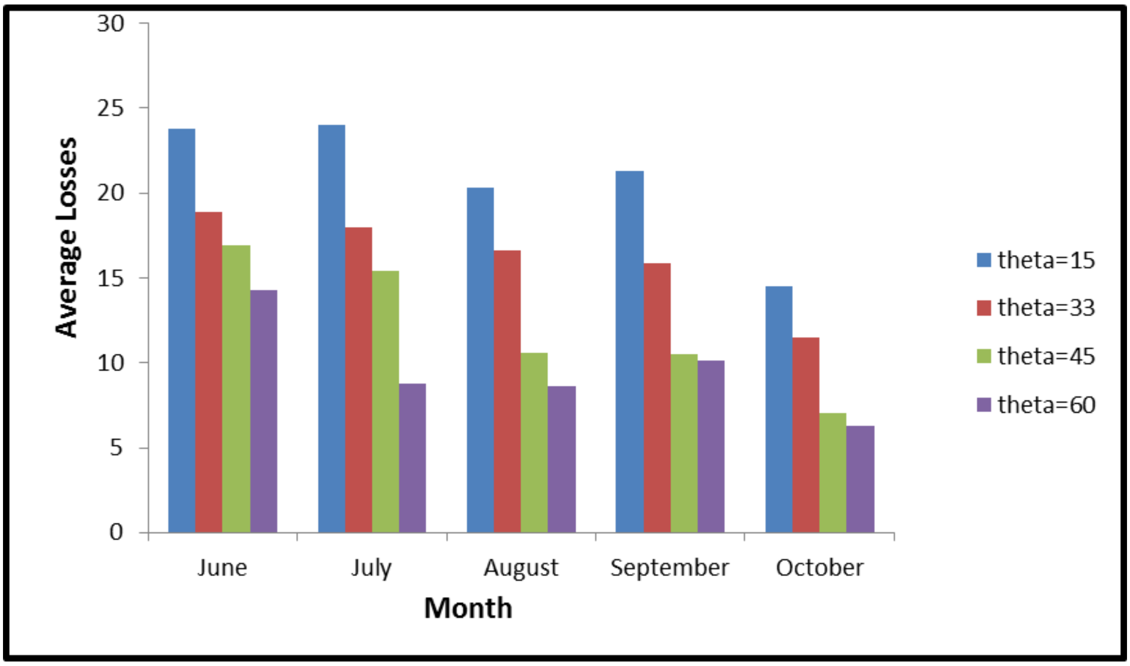
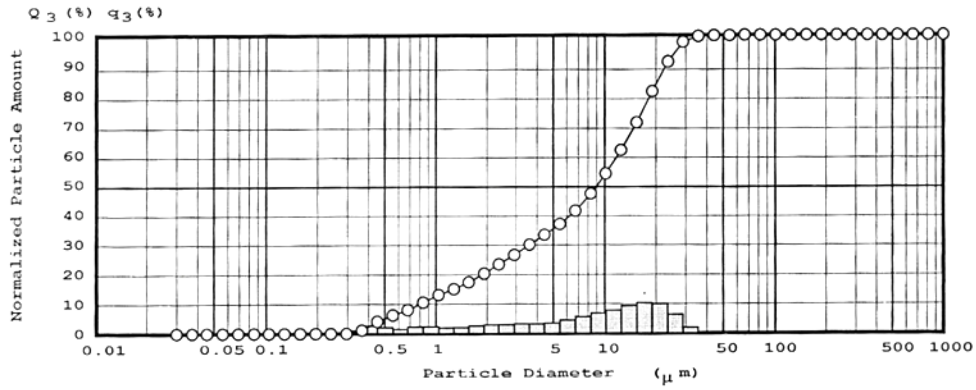


Figure 17. The monthly average loss in the efficiency due to dust in Baghdad for fixed modules at tilt angles (15^o, 30^o, 45^{o}and 60^o).

SHIMADZU SALD-2101 (SALD-2101-WEA1:V1.20)

(File Name)
(Sample ID) m
(Date)
(Sample #)
(Time) 00:41:08

R Index=1.60-0.10i
Median D : 9.116 Mean V : 6.218 10.0%D : 0.798 S Level : 0
Modal D : 17.222 Std Dev : 0.540 50.0%D : 9.146 D Func :Non
75.0%D : 16.800 D Shift : 0



	Diam x(μ m)	Cum Q 3 (%)	Diff q 3 (%)		Diam x(μ m)	Cum Q 3 (%)	Diff q 3 (%)		Diam x(μ m)	Cum Q 3 (%)	Diff q 3 (%)
1	1000.000	100.000	0.000	18	28.988	97.684	6.516	35	0.840	10.462	2.417
2	811.975	100.000	0.000	19	23.538	91.167	9.847	36	0.682	8.046	1.696
3	659.303	100.000	0.000	20	19.112	81.321	10.400	37	0.554	6.350	2.213
4	535.337	100.000	0.000	21	15.518	70.921	9.276	38	0.450	4.137	2.846
5	434.680	100.000	0.000	22	12.601	61.645	7.857	39	0.365	1.291	1.177
6	352.949	100.000	0.000	23	10.231	53.788	6.834	40	0.297	0.114	0.112
7	286.586	100.000	0.000	24	8.308	46.953	5.774	41	0.241	0.002	0.002
8	232.700	100.000	0.000	25	6.746	41.179	4.472	42	0.196	0.000	0.000
9	188.947	100.000	0.000	26	5.477	36.706	3.547	43	0.159	0.000	0.000
10	153.420	100.000	0.000	27	4.447	33.160	3.389	44	0.129	0.000	0.000
11	124.573	100.000	0.000	28	3.611	29.771	3.422	45	0.105	0.000	0.000
12	101.150	100.000	0.000	29	2.932	26.348	3.176	46	0.085	0.000	0.000
13	82.131	100.000	0.000	30	2.381	23.172	3.081	47	0.069	0.000	0.000
14	66.689	100.000	0.000	31	1.933	20.091	2.881	48	0.056	0.000	0.000
15	54.149	100.000	0.008	32	1.570	17.210	2.276	49	0.046	0.000	0.000
16	43.968	99.992	0.224	33	1.275	14.934	1.984	50	0.037	0.000	0.000
17	35.701	99.767	2.083	34	1.035	12.950	2.488	51	0.030	0.000	0.000

Sampling Mode : Manual Refractive Index : 1.60-0.10i
Signal Accumulation Count : 1 Interval (sec) : ___ Signal Averaging Count : 64
Max of Absorbance Range : 0.200 Min of Absorbance Range : 0.010
Ultrasonic Dispersion Time (sec) : ___ Waiting Time After Ultrasonic Dispersion(sec) : ___

Figure 18. The relation between particle diameter and normalized particle amount

The Effect of Cement and Admixture Types on the Resistance of High Performance Concrete to Internal Sulphate Attack

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ABSTRACT

This work is concerned with the study of the effect of cement types, particularly OPC and SRPC, which are the main cement types manufactured in Iraq. In addition, study the effect of mineral admixtures, which are HRM and SF on the resistance of high performance concrete (HPC) to internal sulphate attack. The HRM is used at (10%) and SF is used at (8 and 10)% as a partial replacement by weight of cement for both types. The percentages of sulphate investigated are (1,2 and 3)% by adding natural gypsum as a partial replacement by weight of fine aggregate. The tests carried out in this work are: compressive strength, flexural strength, ultrasonic pulse velocity, and density at the age of 7, 28, 90 and 120 days.

The results indicated that the SRPC mixes showed lower reduction in the properties of concrete compared to OPC mixes at all ages of test. The greatest reduction in compressive strength was at the age of (90) days for OPC mixes and the age of (28) days for SRPC mixes. After that, the concrete showed the lower reduction for all percentages of sulphate in fine aggregate. The results also indicated that the performance of HRM showed better results than the SF, and the replacement of 10% SF exhibits better results than 8% SF for both types of cement.

Key words: high performance concrete , internal sulphate attack , ordinary portland cement, sulphate resisting portland cement , high reactivity metakaolin , silica fume.

تأثير أنواع السمنت والمضافات على مقاومة الخرسانة عالية الأداء لهجوم الكبريتات الداخلية

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الخلاصة

يتناول البحث دراسة تأثير أنواع السمنت وخاصة السمنت البورتلاندي الاعتيادي والسمنت البورتلاندي المقاوم وهي من الانواع الرئيسية المصنعة في العراق، بالأضافة الى دراسة تأثير المضافات المعدنية وهما الميتاكاؤولين عالي الفعالية ودقيق السليكا على مقاومة الخرسانة عالية الاداء لهجوم الكبريتات الداخلية. تم استعمال الميتاكاؤولين عالي الفعالية بنسبة (10) % ودقيق السليكا بنسبة (10,8)% كأستبدال جزئي من وزن السمنت لكلا النوعين. وللحصول على المستويات الملحية بنسبة (1 ,3,2)% ،تم أضافة جبس طبيعي كأستبدال جزئي من وزن الركام الناعم.

في إطار هذا البحث تم إجراء أربعة أنواع من الفحوص هي: مقاومة الأنضغاط ، مقاومة الأنثناء، سرعة الموجات فوق الصوتية، والكثافة في أعمار(7 ,28 ,90 ,120) يوم. وأشارت النتائج بأن خلطات السمنت البورتلاندي المقاوم أظهرت نقصان أقل في خصائص الخرسانة مقارنة بخلطات السمنت البورتلاندي الأعتيادي ولكافة أعمار الفحص. حيث كان أعظم نقصان بمقاومة الأنضغاط بعمر (90) يوم لخلطات السمنت البورتلاندي الأعتيادي وعمر (28) يوم لخلطات السمنت البورتلاندي المقاوم. ولكن بعد ذلك أظهرت الخرسانة نقصان أقل لكل نسب الكبريتات في الركام الناعم. كما بينت النتائج بأن الخلطات الحاوية على الميتاكاؤولين عالي الفعالية أظهرت نتائج أفضل من الخلطات الحاوية على دقيق السليكا، وإن أستبدال (10)% من دقيق السليكا كانت أفضل من (8)% من دقيق السليكا ولكلا النوعين من السمنت.

• **الكلمـات الرئيسـية** : خرسـانة عاليـة الأداء، هجـوم الكبريتـات الداخليـة، السـمنت البورتلانـدي الأعتيـادي، السـمنت البورتلاندي المقاوم، الميتاكاؤولين عالي الفعالية ، دقيق السليكا.

1. INTRODUCTION

High performance concrete (HPC) is concrete with properties or attributes which satisfy the performance criteria. The improved pore structure of high performance concrete is mainly achieved by the use of chemical and mineral admixtures. HRWRA allow substantial reduction in the mixing water. Mineral admixtures provide additional reduction to porosity and improve the interface with the aggregate and hence enhanced durability performance.

Most applications of high performance concrete to date have been in high rise building, long span bridges and some special structures. Generally, concretes with higher strength and attributes superior to conventional concretes are desirable in the construction industry and result economical advantages. Therefore high performance concrete can be considered a logical development of concretes in which the constituents are proportioned and selected to contribute efficiently to the various properties of concrete in fresh as well as in hardened states. **Prassad & Jha, 2005**.

Concrete durability is important, it may deteriorates due to several causes among them are: sulphate attack, corrosion of the reinforcement, alkali- aggregate reactivity, freezing and thawing. Sulphate attack which is the subject of this research and it seems to be the most common cause of concrete deterioration in Iraq. Sulphate attack can be external or internal. This work focuses on the durability of HPC to internal attack related to sulphate within the fine aggregate for both types of cement (OPC and SRPC). This type of attack occurs in different types of concrete structures which justifies the purpose of the use of OPC in the resistance of internal sulphate attack.

2. Internal Sulphate Attack

Sulphates are found in concrete mix from internal sources such as aggregates, cement, and water. These sulphate react with cement paste to form calcium sulphoaluminate. Calcium sulphate (gypsum) is considered more important for this type of attack, because of the addition of gypsum to the cement at the grinding stage to control the hydration speed and the setting of cement paste. Calcium sulphate is about 95% of the total sulphate in the Iraqi sand. **Al-Khalaf, 1983**.

Al-Rawi, 1981 stated that the presence of sulphates in sand or in any concrete constituent will cause reaction with some cement compounds, mainly C_3A. Such a reaction was associated with considerable increase in solid volume. This may be harmful to concrete structure because of the large stresses induced. This harmful effect was demonstrated by a larger reduction in compressive strength which was apparent at early ages (as early as 3 days). This reduction will increase with time if the sulphate content was high, but it will be minimized by autogenous healing if the sulphate content was low, as in this case it depleted within a short period after casting concrete.

Al-Rawi, 1985 pointed out that, a major cause of failure of concrete structures in the Middle East was the contamination of sand with sulphates in the form gypsum. The research pointed that the gypsum is normally added to cement to retard early hydration and prevent quick set. The total sulphate in concrete may, therefore, be high enough to cause internal sulphate attack. This may led to deterioration and possibly cracking and failure of concrete structures. To avoid the adverse effects of sulphates, several specifications put an upper limit on sulphate content in aggregates or on total sulphates in concrete. In some countries, however, it is difficult to find aggregates with the required low sulphates content. In other countries, the supply of sulphate free aggregate may not be indefinite.

This investigation shows that it is possible to reduce the gypsum added to cement and consequently raise the upper limit of sulphate content in aggregate. This will allow the use of huge reserves of sand, hitherto not allowed, with no durability risk or undue loss in concrete strength. The reduction in gypsum, however, will reduce the grinding efficiency. But this may be overcome by the addition of a small percentage of pozzolan or lime. Reduction of gypsum will also cause a slight decrease in setting time of cement, but pozzolan addition will restore the original setting time.

Al-Robayi, 2005 investigated the resistance of normal and high performance concrete exposed to external and internal sulphate attack. The research used high reactivity metakaolin as a partial replacement by weight of cement. The research reached the following conclusions:

- HPC showed better resistance to both external and internal sulphate attack than normal concrete.
- In internal sulphate attack, there was a reduction in strength at early ages (less than 28 days) for normal and HPC. The reduction was positively correlated to the SO_3 presented in fine aggregate. At later ages (more than 28 days) in HPC, the reduction in strength decreased while in normal concrete increased continuously. The pozzolanic action of HRM could be the cause of strength improvement.

Al-Janabi ,2007 investigated the behavior of high performance concrete exposed to internal sulphate attack. Two types of pozzolans were used HRM and FA with OPC and one type of pozzolan was used HRM with SRPC, as a partial replacement by weight of cement. Results indicated that the SRPC gave the same reduction in strength of OPC, and the reduction in strength was increased with the increase of (SO_3)% in fine aggregate, but they regained strength after the consumption of C_3A. The study also showed that HRM gave higher strength than FA in all ages of the tests because of the higher reactivity of metakaolin compared to fly ash.

3. EXPERIMENTAL WORK

3.1 Materials

3.1.1 Cement

Two types of Portland cement are used in this work. The first is ordinary Portland cement (OPC) and the second is sulphate resisting Portland cement (SRPC). Both are produced in Iraq commercially known as (**TASLUJA**) for OPC and (**Al-JESER**) for SRPC. The chemical analysis of the two types of cement are given in **Tables 1 and 2** respectively. The results conform to the Iraqi specification **IQS No.5/1984**.

3.1.2 Fine aggregate

Natural sand from **Al-Ekhadir** region is used for concrete mixes of this work. The grading and physical properties within the limit specified by Iraqi standard **IQS No.45/1984**, as shown in **Table 3**.

3.1.3 Coarse aggregate

Crushed gravel has been used as a coarse aggregate with a maximum size of (10 mm). It is obtained from Al-Nibaee region. The grading and physical properties within the limit specified by Iraqi standard **IQS No.45/1984**, as shown in **Table 4**.

3.1.4 Mixing water

Tap water is used in preparing all mixes.

3.1.5 High range water reducing admixture (HRWRA)

A high range water reducing admixture (superplasticizer) commercially known as **EUCOBET SUPER VZ** manufactured by Swiss Chemistry Company. This type of admixture conforms to the **ASTM C494 type G**.

3.1.6 Mineral admixtures

- **High reactivity metakaolin (HRM)**

Kaolin is a local Iraqi material. It has been grinded by air blast to obtain high fineness of kaolin, then burned in a controlled temperature furnace for one hour at 700C°. The chemical composition and physical properties of HRM are shown in **Table 5**. HRM used in this work conforms to the requirements of **ASTM C618-03**.

- **Silica fume (SF)**

The chemical composition and physical properties of SF are shown in **Table 6**. SF used in this work conforms to the requirements of **ASTM C1240-03.**

- **Strength activity index**

The strength activity index for HRM is performed according to **ASTM C311-02** and for SF according to **ASTM C1240-03.** **Table 7** shows the strength activity index for mortars.

3.1.7 Natural gypsum

The natural gypsum (**$CaSO_4.2H_2O$**) has been grinded by the hammer and passed through the same sieves of sand, and then added. The natural gypsum contains (43.73%) of SO_3, which quantity added to the sand is measured according to this equation:

$$W=(R-M\%)\times S/N \quad \mathbf{(1)}$$

Where:
W: the required weight of natural gypsum (kg);
R: the percentage of SO_3 desired in sand;
S: the weight of sand in mix (kg);
M: the actual SO_3 in sand (0.32%);
N: the percentage of SO_3 in the used natural gypsum (43.73%).

The sand has been reduced relative to gypsum added in the mix.

3.2 Mix Design

Design of HPC mixes to achieve characteristic compressive strength of 50 MPa at 28 days, are made according to the American Method **ACI 211.4R-93** as shown in **Table 8**. The cement content is (513 kg/m³) and the W/C is 0.32. The slump required for all mixes is (100 mm). According to the mix design procedure, the mix proportion is (**1: 1.21: 2.03**). Then These mixes have been studied by adding different percentages of sulphate in fine aggregate of (1, 2 and 3)%, at the age of 7, 28, 90, and 120 days.

3.3 Preparation of Concrete Mixes

The mixing process is performed by hand mixing according to **ASTM C192-02.** Firstly, the sand is well mixed with the gypsum to attain a uniform mix. After that the cement is mixed with required quantity of HRM or SF powder then added to the mix. Finally, the gravel is added to the mix and the whole dry materials are well mixed for about 2 minutes. The required amount of tap water and HRWRA will be added gradually and the whole constituents are mixed for further 2 minutes to get a homogenous mix.

After mixing, the concrete mix is placed in the steel moulds after lubricating them with oil to avoid adhesion with concrete after hardening. The specimens are compacted using a vibrating table for sufficient period, in addition to the use of a metal rod to remove any entrapped air as much as possible. Then the concrete surface is leveled and smoothed by means of trowel, and the specimens are covered with nylon sheet for 24 hrs. After that the moulds are opened and cured until testing date.

3.4 Measurement of Workability of Concrete

A slump test is a suitable test to determine the workability for all types of concrete mixes; the test is performed according to **ASTM C143-00**.

Many attempts of slump test have been carried out to choose the appropriate dose of HRWRA to give equal workability of (100 mm) slump for all mixes, which is (1%) by weight of cement for mix containing (10%) HRM and (1.4 and 1.6)% by weight of cement for mixes containing (8 and 10)% SF respectively, as shown in **Table 8**.

3.5 Testing of Hardened Concrete

3.5.1 Compressive strength: The compressive strength test is performed according to the **British Standard B.S. 1881-part 116-1989** , on 100 mm cubes as shown in **Figs.1and 2**. (No. of specimens are 324)

3.5.2 Flexural strength: (100*100*400) mm concrete beams are used for testing as shown in **Fig.3**. The test is carried out according to **ASTM C293-02.** (No. of specimens are 192)

3.5.3 Ultrasonic pulse velocity (U.P.V.): Concrete cubes (100*100*100) mm are used in this test according to **ASTMC597-02,** using a device commercially known of (PUNDIT) as shown in **Fig.4**. (No. of specimens are 288)

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3.5.4 Density: (100*100*100) mm concrete cubes are used for density test. The density of concrete cubes is determined in dry air by measuring the dimensions and weight of specimens using the measurement feet (vernier) and the electrical scale. The test is performed according to **ASTM C642-97.** (No. of specimens are 288)

4. RESULTS

4.1 Compressive strength

The results indicate that the compressive strength decreases with the increase of sulphate content compared to the reference HPC (0.32%) SO_3 for OPC and SRPC mixes at all ages of test, as shown in **Figs. 5 to 11**.

The results of OPC mixes can be explained as follows:

For mix (MI10), which contains (10%) HRM with OPC, the greatest reduction is (8.20, 13.81, 17.54)% at (90) days and the reduction decreases after that age of (1, 2 and 3)% SO_3 in fine aggregate respectively. While for the mixes (SI8) and (SI10), containing (8%) SF and (10%) SF with OPC respectively, the greatest reduction is (13.66, 20.25, 23.87)% and (10.85, 16.67, 19.51)% at (90) days for (SI8) and (SI10), but the reduction decreases after that age of (1, 2 and 3)% SO_3 in fine aggregate respectively.

Concerning the results of SRPC mixes, they are shown as follows:

For mix (MV10), which contains (10%) HRM with SRPC, the greatest reduction is (7.51, 12.44, 15.03)% at (28) days, but the reduction decreases after that age at 90 and 120 days of (1, 2 and 3)% SO_3 in fine aggregate respectively.

Whereas for the mixes (SV8) and (SV10), containing (8%) SF and (10%) SF with SRPC respectively, the greatest reduction is (11.30, 16.34, 19.25)% and (9.33, 14.20, 18.01)% at (28) days for (SV8) and (SV10) respectively. The reduction decreases after that age at 90 and 120 days of (1, 2 and 3)% SO_3 in fine aggregate respectively.

4.2 Flexural strength

The results indicate that the flexural strength decreases with the increase of sulphate content compared to the reference HPC (0.32%) SO_3 for OPC and SRPC mixes at all ages of test as shown in **Figs. 12 to 18**.

The results of OPC mixes can be explained as follows:

For mix (MI10), the greatest reduction is (3.21, 6.54, 8.57)% at (28) days. After that age of the test, in (90, 120) days there is an improvement in the regain of the flexural strength of (1, 2 and 3)% SO_3 in fine aggregate respectively.

Whereas for the mixes (SI8) and (SI10), the greatest reduction is (7.44,9.88, 10.78)% and (5.72, 7.43, 9.50)% at (28) days for (SI8) and (SI10) respectively. The reduction decreases after that age at 90 and 120 days of (1, 2 and 3)% SO_3 in fine aggregate respectively.

Concerning the results of SRPC mixes, they are shown as follows:

For mix (MV10), the greatest reduction is (2.27, 4.77, 7.38)% at (28) days, but the reduction decreases after that age of (1, 2 and 3)% SO_3 in fine aggregate respectively.

While for the mixes (SV8) and (SV10), the greatest reduction is (5.86, 7.33, 9.16)% and (4.52, 6.26, 7.88)% at (28) days for (SV8) and (SV10) respectively. The reduction decreases after that age of (1, 2 and 3)% SO_3 in fine aggregate respectively.

4.3 Ultrasonic pulse velocity

The results demonstrate a slight decrease in pulse velocity with the increase of sulphate content compared to the reference HPC (0.32%) SO_3 for OPC and SRPC mixes at all ages of test. The ultrasonic pulse velocity results for mixes of OPC show the greatest reduction at (90) days and the reduction improve after that age at (120) days. Whereas the ultrasonic pulse velocity results for mixes of SRPC show a greatest reduction at (28) days and the reduction improve in (90 and 120) days. **Fig. 19** shows the effect of sulphate content in fine aggregate on UPV at 120 days for OPC and SRPC mixes.

4.4 Density

The results show that the mixes of OPC and SRPC exhibit an increase in density with the increase of sulphate content in fine aggregate at all ages of the test. Generally, the results show a slight increase in density relative to reference HPC (0.32%) SO_3.

Fig. 20 shows the effect of sulphate content in fine aggregate on density at 120 days for OPC and SRPC mixes.

5. DISCUSION

There are many variables that affect the strength development of different mixes. These variables are: type of portland cement (OPC and SRPC), the effect of pozzolanic materials (HRM and SF), and SO_3 in fine aggregate.

5.1 Effect of Cement Composition

The cement composition difference and relative amounts of hydration products between the OPC and SRPC are likely to be responsible for the differences in strength results.

The durability in a sulphate attack depends mainly on C_3A content of cement. Thus, it can be considered the chief contributor to volume change in sulphate attack. **Shanahan, and Zayed, 2007**.

As shown in **Tables 1 and 2**, the C_3A of OPC and SRPC are (10.04, 2.00)% respectively. The greater C_3A content will influence the relative amounts of ettringite and monosulphate (calcium aluminate hydrates) initially formed on hydration, and hence the propensity for expansion by ettringite formation upon sulphate. In addition, any unhydrated C_3A remaining may also result in ettringite formation and expansion. Because the high C_3A content, OPC contains more ettringite and monosulphate than the SRPC. **Naik et al., 2006**

The low C_3A leads to an increase in other compounds of cement (C_3S, C_2S). These two compounds are responsible for strength on the one hand and the high fineness of SRPC which increases the surface area of the (C_3S, C_2S) on the other hand. **Neville, 2002, Shanahan, and Zayed , 2007**

The result of the reaction of C_3A with gypsum depends on the C_3A content of cement by forming: **Al-Khalaf, 1983**

a. Calcium sulphoaluminate (ettringite), containing a high sulphate ($C_3A.3CaSO_4.32H_2O$), when the content of C_3A is high.

b. Calcium sulphoaluminate, containing a low sulphate ($C_3A.CaSO_4.12H_2O$), when the content of C_3A is low.

In spite of that the durability in sulphate attack is not dependent on the C_3A content of cement only. **Shanahan, and Zayed, 2007** have mentioned that the other chemical components in the cement that control permeability such as C_3S/C_2S ratio, help to control the rate and severity of sulphate attack. Increasing C_3S content or C_3S/C_2S ratio in cement generates more $Ca(OH)_2$ on hydration. This has possibly two effects. First, higher lime content in cement limits the solubility of aluminates and retards hydrated calcium aluminates. Second, lime availability increases formation of ettringite. While, cement containing lower amounts of C_3S show improvement of sulphate resistance.

Odler, and Jawed, 1991, have explained that C_4AF also produces ettringite, but at a reaction rate much slower than C_3A, and the resulting ettringite crystals contain iron along with aluminum in the lattice.

As noted in **Tables 1 and 2**, C_4AF of OPC and SRPC are (9.97, 14.47)% respectively. The effect of the greater relative amount of C_4AF in SRPC as compared to the OPC needs to be considered. Due to the greater quantity of C_4AF, ettringite formed in SRPC during sulphate attack is likely to be Fe-substituted. The iron-substituted ettringite is not expansive or less expansive. However, in order to achieve this, the Al_2O_3/Fe_2O_3 ratio in C_4AF is decreased by the addition of iron, which in turn raises the C_4AF content. **Naik et al., 2006, Tikalsky et al., 2002.**

Neville, 2002 has stated that the C_4AF reacts with gypsum to form calcium sulphoferrite as well as calcium sulphoaluminate, and its presence may accelerate the hydration of the silicate. In addition, this compound may form a protective film over C_3A; thus, the reaction of C_3A with sulphate ions will be reduced therefore, this compound is more resistance to sulphate attack than C_3A.

Tikalsky et al., 2002 have reported that the C_3A content is not the primary factor controlling sulphate attack, but C_4AF is the most beneficial in controlling sulphate attack.

5.2 Effect Type of Pozzolan

The HRM provides higher strength results compared to SF for both types of cement. This may be either due to the HRM consumes a significant proportion of the lime produced by the cement hydration to form more (C-S-H) gel than SF, or due to the lower surface area of HRM than SF. The possibly, high surface area of SF leads to more increase in the surface reaction between C_3A and sulphate ions.

In addition, the mix containing (10%) SF has higher strength results than (8%) SF for both types of cement. Generally, this can be explained by the following mechanisms. First, the replacement of a more portion of Portland cement with SF reduces the total amount tricalcium aluminate hydrate. Thus, the quantity of expansive ettringite will be less in the cement paste of concrete. The second mechanism is through the pozzolanic reaction between the SF and $Ca(OH)_2$ released during the hydration of cement, which consumes part of the $Ca(OH)_2$. Furthermore, the formation of secondary (C-S-H) by the pozzolanic reaction produces a film or a coating on the alumina-rich and other reactive phases thereby hindering the formation of ettringite**., Zelic et al., 2007.**

The different components of the two pozzolanic materials can be the direct reason for the difference in strength activity. The major components responsible for the pozzolanic reaction of HRM are silica (SiO_2) and alumina (Al_2O_3). **Headwater resources, 2005**, as the pozzolanic reaction of SF depends mainly on amorphous SiO_2. **ACI 234R-96**

From the chemical analysis of pozzolanic materials, the sum percentage of Al_2O_3 and SiO_2 for HRM is 93.12%, more than the percentage of SiO_2 in SF which is 88.30%. The pozzolanic reaction take place between the components mentioned above in pozzolanic material (HRM and SF) and calcium hydroxide formed during the hydration process. This leads to the more cementitious compound produced from the reaction of HRM than SF and leads to densification of the concrete matrix resulting increase in strength for the same type of cement.

The C_3A content of cement should be regarded when discussing the effect of pozzolanic materials on the type of cement as **Lea, 1970** has reported that the pozzolanic cements prove resistant in the test if made of Portland cement of low C_3A content but not exceptionally high content of reactive silica.

Neville, 2002 has indicated that the replacement of low C_3A content cement (i.e. sulphate resisting cement) with pozzolan, provide a better performance in sulphate resistance.

Kalousek et al., 1972 have reported that partial pozzolana replacement of sulphate resisting cement is very effective in making the concrete resistant to sulphate attack but that is related to SiO_2: R_2O_3 ratio in the pozzolana.

According to **Lea, 1970** the pozzolan containing high SiO_2 nearly (90%) and low R_2O_3 (Al_2O_3 + Fe_2O_3) can increase the sulphate resistance of SRPC.

As reported by **Cao, et al., 1997** that the sulphate resistance of pozzolanic materials is dependent on its composition.

In spite of that the SF has a high SiO_2 and low Al_2O_3, but it does not prove an effective subsistent for enhancing the sulphate resistance than HRM for the same type of cement.

Concerning the results of density and ultrasonic pulse velocity, SF has higher results than HRM for both types of cement due to the higher fineness of SF than HRM that leads to filling the pores and to cut the continuity of capillary pores.

The density results increase with the increase of (SO_3%) in fine aggregate. This can be attributed to the presence of ettringite which leads to a denser structure as a result of precipitation of ettringite within voids and microspores. **Zelic et al., 2007.**

5.3 Effect of sulphate content in fine aggregate

Gypsum ($CaSO_4.2H_2O$) is the main source of sulphate in cement, sand, and coarse aggregate. It has significant effect on the concrete strength.

The increase of (SO_3%) in fine aggregate causes an increase in the reduction of strength results and the reduction decreases at later ages. Generally, this can be attributed to the pozzolanic reaction which increases the amount of hydration products and reduces the tricalcium aluminates in cement. As reported by **Al-Rawi, 1981** that the autogenuous healing may take place in internal sulphates at later ages when pozzolan replaces Portland cement and result in an improving in compressive strength. In addition to the pozzolanic reactions, they also have possibly another reason either due to the consumption of calcium sulphate while the C_3A is still hydration. Thus, the ettringite decomposes into the more stable compound, monosulphate, or due to the consumption of C_3A while calcium sulphate is still in free state (with no reaction that causes expansion and deterioration in HPC. **Al-Khalaf, 1983, Minard et al., 2007**

But the reaction will be slow over time due to the consumption of salts. Thus, the effect of salts on the strength of concrete is more clearly in the early ages than the later ages for this type of attack. **Al-Nakshabandy, 2005**.

The purpose of adding (SO_3%) to fine aggregate is because of its high surface area compared to coarse aggregate. This leads to more increase in the surface reaction between C_3A and sulphate ions. As **Al-Salihi, 1994** has stated that SO_3 from sand has more effect than SO_3 from coarse aggregate. The difference between the effects is quite large as in the case of cement and sand.

While the work done by **Ali**, **1981** has shown that SO_3 from cement has more destructive effect on concrete strength compared to the effect of the same amount of SO_3 from sand. This is attributed to the finer cement grains compared to sand grains. Finer grains mean higher surface area and higher rate of solubility and reaction of SO_3 in the form of gypsum in cement or sand.

The adopted percentages of (SO_3%) in the present work are (1, 2 and 3)%, all of the percentages have been compared to the reference of (0.32%) SO_3, which is less than the allowable (SO_3%) in Iraqi specification (**IQS**).

In addition, the internal resistance of concrete depends on the total SO_3 content and must not exceed certain upper limit. (SO_3Tot.) of HPC is calculated according to (IQS No.45/1984). IQS indicate that the maximum content of SO_3 in concrete mixes is (4%) by weight of cement, when cement content ($\geq$ 300 kg/m³) and SO_3 in fine aggregate is (0.5%).

$$\mathbf{SO_{3Tot.}} = A + (Y/X)\times B + (Z/X)\times C + (L/X)\times D \qquad \textbf{(2)}$$

Where:
A: SO_3 content in cement.
B: SO_3 content in fine aggregate.
C: SO_3 content in coarse aggregate.
D: SO_3 content in pozzolan.
X: weight of cement.
Y: weight of fine aggregate.
Z: weight of coarse aggregate.
L: weight of pozzolan.

6. CONCLUSIONS

1. High reactivity metakaolin shows higher strength than the silica fume in all ages of the test for both types of cement (OPC and SRPC).

2. The employment 10% of SF as a partial replacement by weight of cement exhibits higher strengths at all ages of test than 8% of SF. However, the 10% of HRM indicates superior performance in the resistance of HPC to internal sulphate attack than (8 and 10)% SF for both types of cement.

3. In ultrasonic pulse velocity and density tests, the maximum results in ultrasonic pulse velocity and density are noted with 10% SF followed by 8% SF and 10% HRM for both types of cement. However, there is not much of a difference between the performance of 8% SF and 10% HRM.

4. Sulphate resisting portland cement shows the lower reduction in strength than ordinary portland cement for mixes containing of 10% HRM and SF at (8 and 10)%.

5. The reduction in strength tests increases with the increase of (SO_3%) in fine aggregate at all ages of test, but the reduction decreases at later ages because the pozzolanic reactions can be the cause of strength improvement for OPC and SRPC mixes. There is an improvement in the regain of strength after age of (28 and 90) days for SRPC and OPC mixes respectively.

6. The resistance of HPC to internal sulphate attack depends mainly on the chemical composition of cement.

7. The alumina in pozzolanic material has not its effect on the resistance of HPC to (SO_3%) in fine aggregate. Thus, it cannot be considered as additional source to react with SO_3. Whereas HRM has higher alumina if compared with SF (Al_2O_3 for HRM =34.65%, and for SF= 0.35%), but it gives higher resistance of HPC to internal sulphate attack than SF for both types of cement.

8. Under the sulphate within the fine aggregate up to about 3%, HPC mixes of OPC and SRPC does not suffer significantly deterioration in all its properties. (SO_3Tot.) generally is not much higher than the allowable limit of (SO_3) in concrete. The (SO_3Tot.) for high sulphate content of (3%) SO_3 in fine aggregate is (5.64, 5.69, 5.71)% for mixes containing 10% HRM, 8% SF and 10% SF with OPC, and (5.46, 5.51, 5.53)% for mixes containing 10% HRM, 8% SF and 10% SF with SRPC respectively.

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NOMENCLATURE

Notation	Description
HPC	High Performance Concrete
HRM	High Reactivity Metakaolin
SF	Silica Fume
HRWRA	High Range Water Reducing Admixtures
OPC	Ordinary Portland Cement
SRPC	Sulphate Resisting Portland Cement
U.P.V.	Ultrasonic Pulse Velocity
SO_3Tot.	Total Sulphate Content in Concrete
MI10	Mix of OPC and 10% Metakaolin
SI8	Mix of OPC and 8% Silica fume
SI10	Mix of OPC and 10% Silica fume
MV10	Mix of SRPC and 10% Metakaolin
SV8	Mix of SRPC and 8% Silica fume
SV10	Mix of SRPC and 10% Silica fume

Table 1. Chemical composition and main compounds of ordinary portland cement.

Oxide composition	Abbreviation	by weight%	Limits of Iraqi spec. No.5/1984
Lime	CaO	61.30	-
Silica	SiO_2	20.54	-
Alumina	Al_2O_3	5.88	-
Iron oxide	Fe_2O_3	3.28	-
Sulphate	SO_3	1.87	≤ 2.8%
Magnesia	MgO	1.93	≤ 5%
Loss on Ignition	L.O.I.	2.45	≤ 4%

Lime saturation Factor	L.S.F.	0.90	0.66-1.02
Insoluble residue	I.R.	0.15	≤ 1.5%
Main compounds (Bogues eq.)		**by weight of cement%**	
Tricalcium silicate (C_3S)		43.85	
Dicalcium silicate (C_2S)		25.88	
Tricalcium aluminate (C_3A)		10.04	
Tetracalcium aluminoferrite (C_4AF)		9.97	

Table 2. Chemical composition and main compounds of sulphate resisting portland cement.

Oxide composition	Abbreviation	by weight%	Limits of Iraqi spec. No.5/1984
Lime	CaO	60.63	-
Silica	SiO_2	21.63	-
Alumina	Al_2O_3	3.79	-
Iron oxide	Fe_2O_3	4.76	-
Sulphate	SO_3	1.69	≤ 2.5%
Magnesia	MgO	2.72	≤ 5%
Loss on Ignition	L.O.I.	1.94	≤ 4%
Lime saturation Factor	L.S.F.	0.87	0.66-1.02
Insoluble residue	I.R.	0.77	≤ 1.5%
Main compounds (Bogues eq.)		**% by weight of cement**	
Tricalcium silicate (C_3S)		45.28	
Dicalcium silicate (C_2S)		27.93	
Tricalcium aluminate (C_3A)		2.00	
Tetracalcium aluminoferrite (C_4AF)		14.47	

Table 3. Grading and Physical Properties of Fine aggregate

Sieve size (mm)	Passing %	Limits of Iraqi spec. No.45/1984/Zone 2
10	100	100
4.75	100	90-100
2.36	85	75-100
1.18	65	55-90
0.6	50	35-59
0.3	15	8-30
0.15	4	0-10
Physical properties		**Limits of Iraqi spec. No.45/1984**
Fineness modulus: 2.81		-
Specific gravity: 2.5		-
Absorption: 1.6%		-
SO_3: 0.32 %		≤ 0.5%
Dry rodded density: 1780 kg/m³		-

Table 4. Grading and Physical Properties of Coarse aggregate

Sieve size (mm)	Passing%	Limits of Iraqi spec. No.45/1984
37.5	100	100
20	100	95-100
10	48	30-60
4.75	3	0-10
Physical properties		**Limits of Iraqi spec. No.45/1984**
Specific gravity: 2.65		-
Absorption: 0.5%		-
SO_3: 0.06%		≤ 0.1%
Dry rodded density: 1600 kg/m³		-

Table 5. Chemical analysis and physical properties of HRM.

Oxide Composition	Oxide content %	Pozzolan class N ASTM C618-03
SiO_2	58.47	Σ = 94.52%
Al_2O_3	34.65	Min. 70%
Fe_2O_3	1.40	
MgO	0.21	
CaO	0.38	
SO_3	0.21	Max. 4%
Na_2O	0.66	
L.O.I	2.47	Max. 10%
Physical properties		
Specific gravity	2.32	
Fineness (Blaine)	865 m²/kg	
Physical form	powder	
Color	off-white	

Table 6. Chemical analysis and physical properties of SF.

Oxide Composition	Oxide content %	ASTM C1240-03
SiO_2	88.30	Min. 85%
Al_2O_3	0.35	
Fe_2O_3	1.17	
MgO	2.40	
CaO	1.25	
SO_3	0.91	
Na2O	1.37	
L.O.I	3.78	Max. 6%
Physical properties		
Specific gravity	2.016	
Fineness (Blaine)	16000 m²/kg	
Physical form	powder	
Color	grey	

Table 7. Strength activity index for tested mortars.

Mix symbol	Cementitious material content		Fine agg. kg/m³	SO_3 % by wt. of Fine agg.	Coarse agg. kg/m³	Water kg/m³	HRWRA by wt. of cement %	W/Cm	Compressive strength (MPa)	
	Cement kg/m³	Pozzolan kg/m³							7d.	28d.
MI10	461.70	51.30	622	0.32	1040	164	1	0.32	47.54	61.46
SI8	471.96	41.04	622	0.32	1040	164	1.4	0.32	44.36	56
SI10	461.70	51.30	622	0.32	1040	164	1.6	0.32	45	58.60
MV10	461.70	51.30	622	0.32	1040	164	1	0.32	50.36	67.50
SV8	471.96	41.04	622	0.32	1040	164	1.4	0.32	45.43	57.50
SV10	461.70	51.30	622	0.32	1040	164	1.6	0.32	46.53	60.40

Table 8. The details of HPC mixes used throughout this investigation prior addition of sulphate.

Index	Strength activity index%
R	-
HRM	140
SF	108

Figure 1: Specimens of cubes for compressive strength test.

Figure 2: Compressive strength test devise.

Figure 3: Specimens of prism for flexural strength test.

Figure 4: Ultrasonic pulse velocity test.

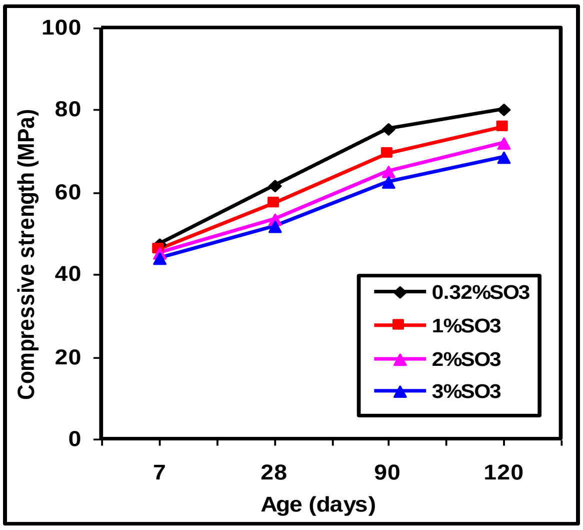

Figure 5. Effect of age on compressive strength with different sulphate content for mix (MI10).

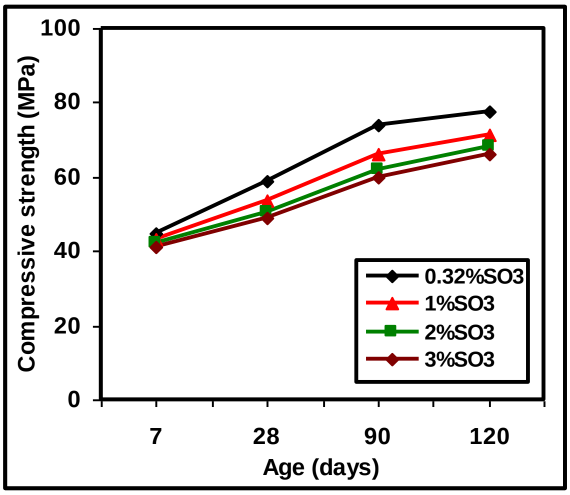

Figure 7. Effect of age on compressive strength with different sulphate content for mix (SI10).

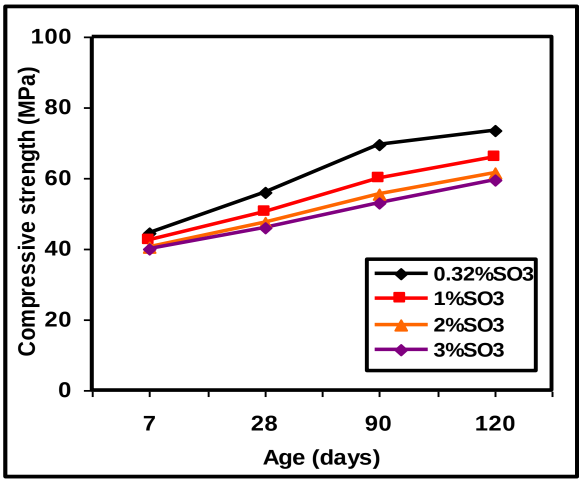

Figure 6. Effect of age on compressive strength with different sulphate content for mix(SI8).

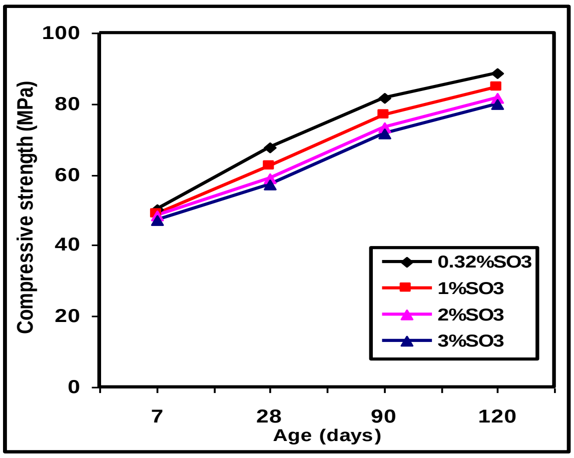

Figure 8. Effect of age on compressive strength with different sulphate content for mix (MV10).

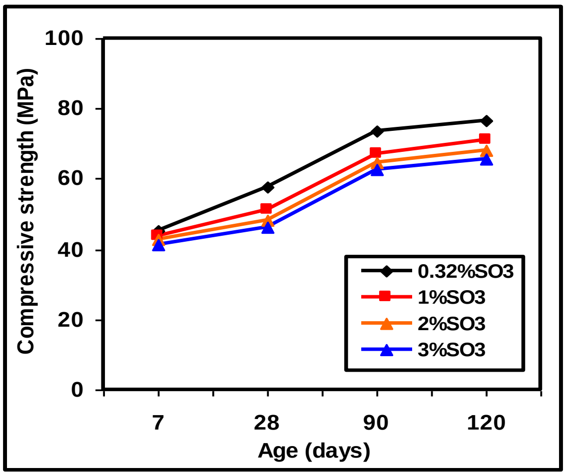

Figure 9. Effect of age on compressive strength with different sulphate content for mix (SV8).

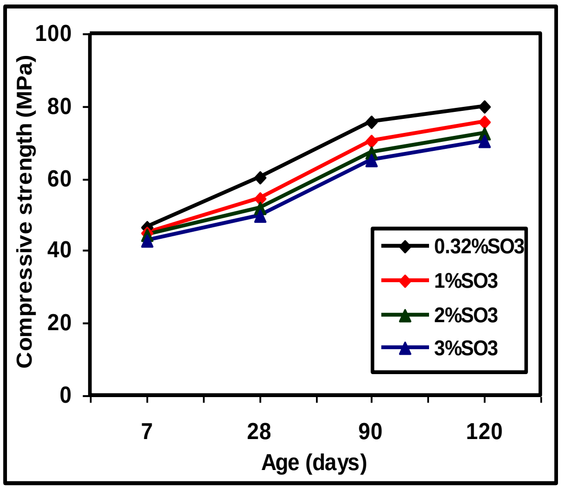

Figure 10. Effect of age on compressive strength with different sulphate content for mix (SV10).

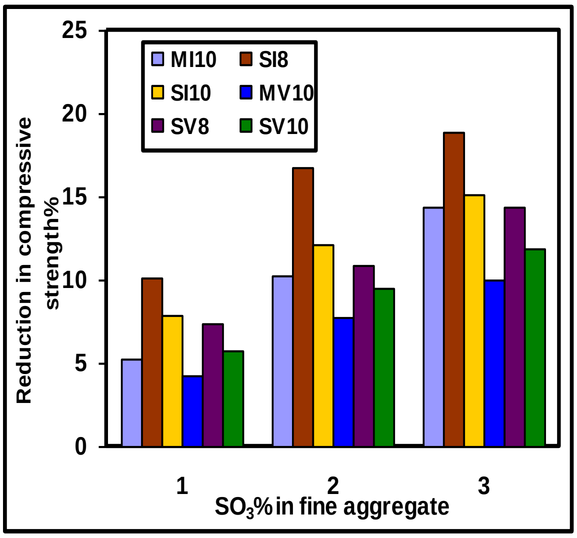

Figure 11. Effect of sulphate content on reduction in comp. strength at 120 days for OPC and SRPC mixes.

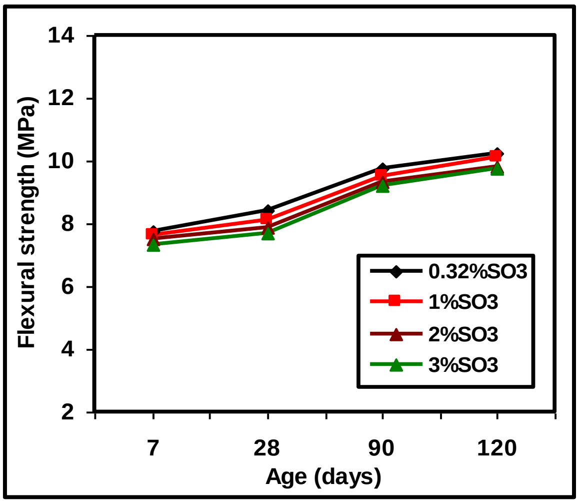

Figure 12. Effect of age on flexural strength with different sulphate content for mix (MI10).

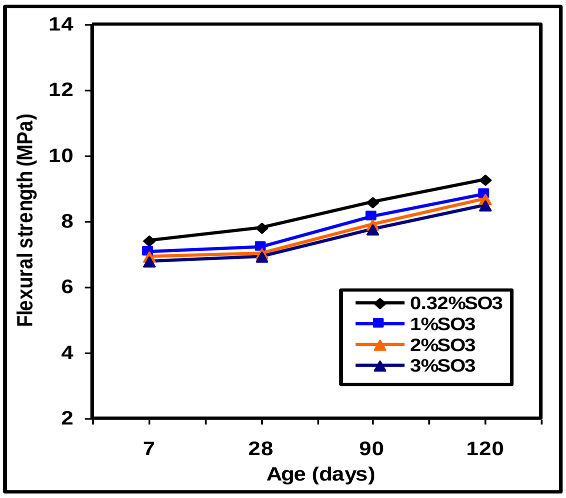

Figure 13. Effect of age on flexural strength with different sulphate content for mix (SI8).

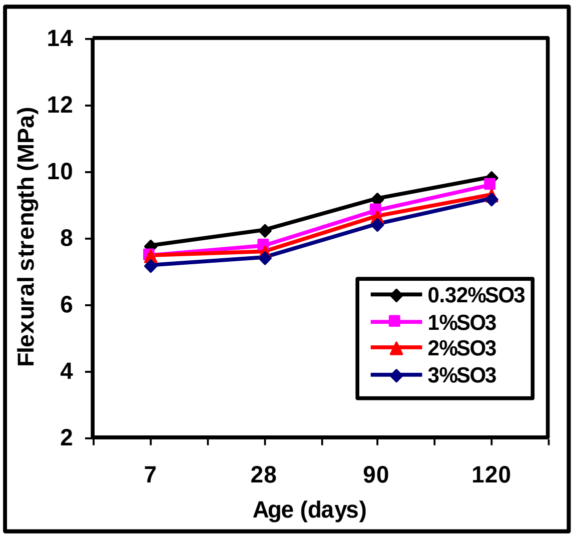

Figure 14. Effect of age on flexural strength with different sulphate content for mix (SI10).

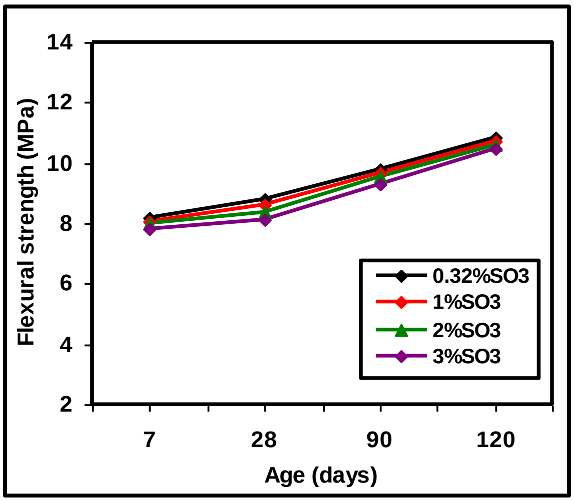

Figure15. Effect of age on flexural strength with different sulphate content for mix (MV10).

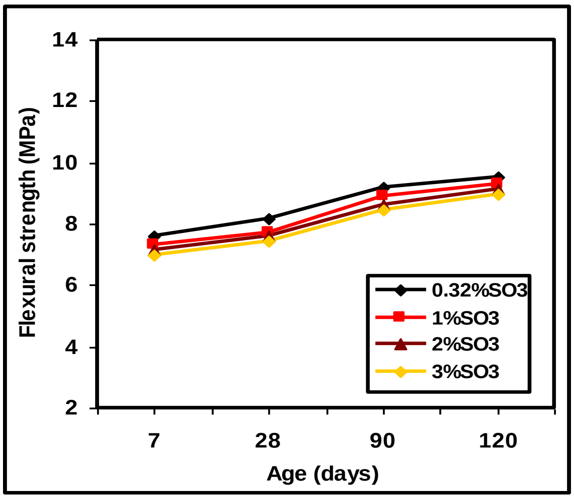

Figure 16. Effect of age on flexural strength with different sulphate content for mix (SV8).

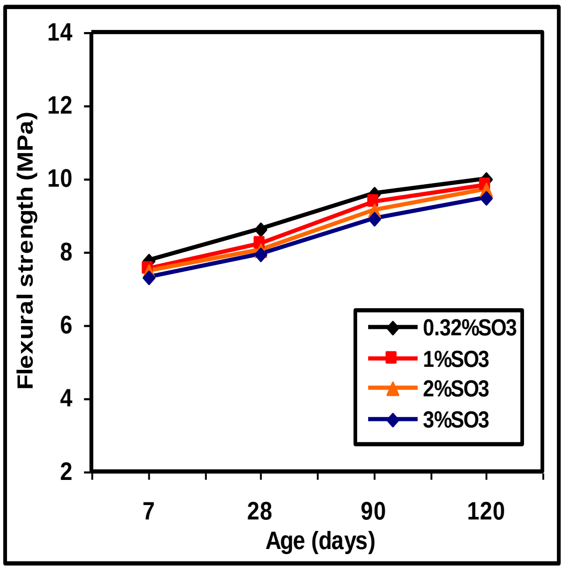

Figure 17. Effect of age on flexural strength with different sulphate content for mix (SV10).

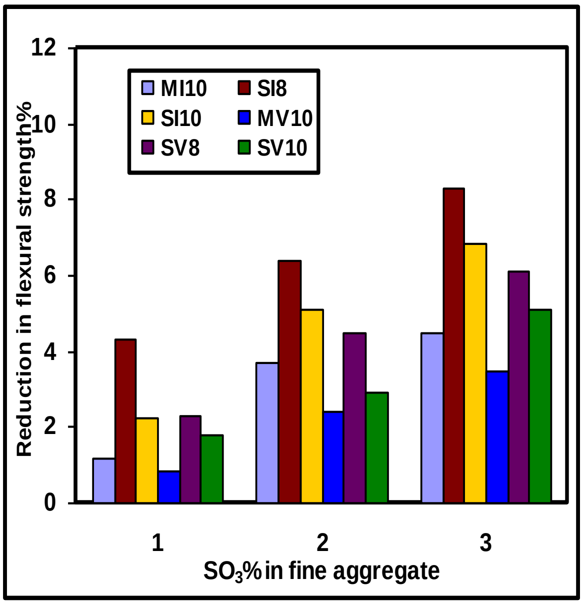

Figure 18. Effect of sulphate content on reduction in flexural strength at 120 days for OPC and SRPC mixes.

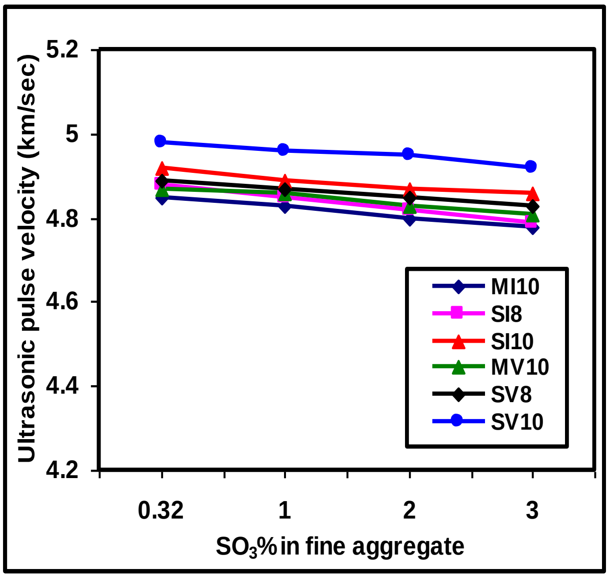

Figure 19. Effect of sulphate content in fine agg. on UPV at 120 days for OPC and SRPC mixes.

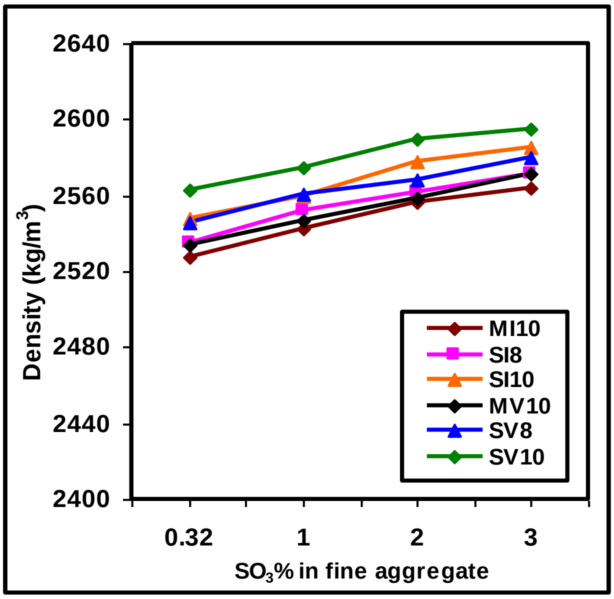

Figure 20. Effect of sulphate content in fine agg. on density at 120 days for OPC and SRPC mixes.

The Most Influential Factor on the Stumble and Failure of the governmental Projects

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ABSTRACT

The governmental projects are considers the prevailing in Iraq, as most of the projects implemented by the Government, the major role played by governmental projects in the provision of services to citizens and improve the economic situation in the country in general, in addition to the huge number of these projects implemented by the governmental organizations and the large failure rates of it , and because of the fact that these projects are stumbled before they reach the stage of failure, The aim of this research to identify the main factors for the stumble projects in addition to identifying the most influential factor on the causes and consequences of it , like (cost overruns , time overruns , delay and scope creep) , the most influential factors have been identified through the questionnaire of thirty three (director manager, project manager and engineer) in the governmental organizations who has extensive experience in project implementation . The factors (political situation, the security and the deteriorating economic, financial efficiency is good for the employer, the contractor and low-budget experience, poor design and lack of efficient manpower and resources) of the most important factors that lead to stumble projects.

Keywords: stumble projects, cost overruns, time overruns, and scope creep.

العوامل الاكثر تاثيرا على تعثر وفشل المشاريع الحكومية

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الخلاصة

تعتبر المشاريع الحكومية هي السائدة في العراق ، حيث ان اغلب المشاريع تنفذها الحكومة تقريبا ، و للدور الكبير الذي تلعبه المشاريع الحكومية في تقديم الخدمات للمواطنين و تحسين الوضع الاقتصادي في البلد بشكل عام ، اضافة الى العدد الهائل من هذه المشاريع و التي تنفذها مختلف المنظمات الحكومية و نسب الفشل الكبيرة فيها و بسبب كون هذه المشاريع تكون متعثرة قبل ان تصل الى مرحلة الفشل, كان الهدف من هذا البحث تحديد العوامل الرئيسية لتعثر المشاريع اضافة الى تحديد العوامل الاكثر تاثيرا على اسبابه و نتائجه , مثل (زيادة الكلفة , زيادة الزمن , التاخير و زحف نطاق المشروع), العوامل الاكثر تاثيرا قدد حددت عن طريق الاستبيان لثلاثة و ثلاثين (مدير قسم ، مدير مشروع و مهندس) في المنظمات الحكومية ممن لديه خبرة واسعة في تنفيذ المشاريع و استخدمت طريقة دلفي في هذا الاستبيان كانت عوامل (الوضع السياسي ، الامني و الاقتصادي المتدهور ، الكفاءة المالية غير الجيدة لصاحب العمل ، ميزانية المقاول و خبرته المنخفضة ، ضعف التصميم و قلة الايدي العاملة الكفوءة و الموارد) من اهم العوامل التي تؤدي الى تعثر المشاريع .

الكلمات الرئيسية :تعثر المشاريع, زيادة الكلفة , زيادة الزمن و انحراف نطاق المشروع .

1. INTRODUCTION

Despite well-known research findings and in spite of decades of individual and team expertise of project management, Despite rapid development of membership of professional bodies for managing projects and despite an increase in the quantity of the project active in the industry, Project outcomes continues disappoint the stakeholders , the project would be consider troubled when it is heading towards fail. The troubled project can be defined as the project that the difference between what is expected and what is accomplished exceeds acceptable the tolerance limits, pushing into courses that will inevitably lead to its failure. Whether a troubled project ultimately succeeds or fails depends on the effectiveness of the actions taken to recover the project. Before these actions can be taken, however, organizations need to be able to recognize problems and prepare to take appropriate corrective measures. **Fisher , 2004** , Identified indicators of troubled projects as :

1- Contract work got off to a very slow start.
2- Equipment ordering has fallen far behind schedule.
3- Subcontracted work is being falling behind schedule or assigned late.
4- The owner- information / furnished equipment is arriving incomplete or late.
5- The numerous alleged changes are not negotiated or agreed-upon.
6- Cash liquidity problems of the contractor and/or owner.
7- Continues substantial changes in the project from the owner. **Cleland, 1983**, found that the main causes of troubled projects may come from the following sources:

1. The requirements: imprecise, Continuous Scope Changes, contradictory, lack of priority, lack of agreement, ambiguous and Unclear.
2. The resources: resource conflicts, Lack of resources, Inadequate, turnover of key resources and poor planning.
3. The timetable: overly optimistic, Too tight, and unrealistic.
4. Planning: missing items, insufficient details, poor estimates, Based on insufficient data.
5. Risks: not managed, unidentified or assumed. .

The most important results that obtain at the arrival to troubled phase of the project is the (cost overrun, time overrun, delay and change or creep the scope) , In this research, an identification of the main factors for these results In addition to determining the most influential on the Stumble governmental projects.

2. COST OVERRUN

The Poor cost performance in construction project was a very common problem worldwide lead to a significant amount of cost overrun. Which requires identification of the major contributors of this overrun and to highlight the efficient ways to control it? Cost overrun was defined as excess of the actual cost over budget.

Flyvbjerg et al., 2003. Studied 258 projects in 20 countries and found that the cost escalation was a very common practice and happens in nine out of 10 projects with 28% higher than forecast costs in average. They concluded that the average cost escalation in Europe was 25.7%, in North America 23.6% and in the other geographical areas was 64.6%, they also found that the cost performance in construction projects has not improved over time .the World Bank also indicate that about 63% of the 1778 construction projects financed by it, was faced a poor performance with an average of 40% overrun in budget, **Ameh et al. ,2010. and Zujo et al., 2010**.

In Ghana, the proportion of projects exceeded the original project was 75% of cost, while; only 25% were completed within budget, **Frimpong et al., 2003**. Another investigation of 29 showed that the contracted price overruns were noted at 17 (58.62%) of the projects with a maximum contracted price overrun of 29.16% ,**Zujo et al., 2010.** the major causes of excessive cost overruns in developing countries were ,the poor contractor management, poor technical performances, material procurement, monthly payment difficulties and escalation of material prices . **Frimpong et al.,2003 and Lee ,2008,** examined the problems of cost overrun in Korean social overhead capital projects. he study 161 completed projects , and found that the causes of cost overruns were (the project costs unreasonable estimation and adjustment, delays during construction, changes in scope and no practical use of the earned value). The cash flow and financial difficulties faced by contractors were, contractor's poor site management and supervision, incorrect planning and scheduling, shortage of site workers, inadequate contractor experience , whereas, the changes in the project scope and frequent design changes are the least affecting factors on construction cost , **Sriprasert ,2000. and Memon et al., 2010.** The main affecting causes of cost overrun in Kuwait were: owners' lack of experience, owners' financial constraints, and changing orders, **Koushki et al., 2005.** The roject complexity, inaccurate material estimating, and inflationary increases in material cost were the main causes of cost overrun in Indonesian construction projects, **Kaming et al., 1997.** The conflict among project participants, non-existence of cooperation, presence of poor project specific attributes and ignorance and lack of knowledge, were most factors affecting the cost overrun of construction projects in India , **Iyer et al., 2008.**

3. TIME OVERRUNS

The Time overruns was defined as the time extension beyond planned completion dates .Time overrun has become a major one of the most concern in construction projects worldwide, it is currently a common problem in many projects leading to a considerable losses to the project parties. The Loss of time in construction projects influences drastically on project success and the time performance is the most important indicator of the project success **Olawale. Y.A and M. Sun, 2010.**

the infrastructure projects in India ,experience a time overrun of up to 500% of the original estimated time, **Pai and Bharath ,2013.** in Malaysia , only 20.5% of the public projects and about 33.35% of the private sector projects were completed within original estimated time , **Endut et. al. ,2009.** The , (poor site management and supervision, ineffective project planning and scheduling, inadequate contractor experience, late delivery of materials, design changes by owner during construction, unreliable subcontractors, change orders, unqualified/inexperienced workers, delay in performing inspection and testing, delay in site delivery, slowness indecision making, delay in progress payments, delay in approving design documents , poor communication and coordination) are the time overrun major factors in turkey, **Gündüz et. al. ,2012.** the major factors of time overrun in Egypt are " ineffective planning and scheduling, poor site management and supervision, variation orders/changes, difficulties in financing project by contractor, type of project bidding and award, low productivity level of labors, effects of subsurface conditions, delays in sub-contractors work, shortage of construction materials, and unqualified workforce" , **Marzouk and El-Rasas ,2014.** lack of tower materials in the local markets, unrealistic clients requirements, delays of payments certificates, scope changes, poor workmanship, delay in design work, uncompromising attitudes between parties, unethical behavior of contractors to achieve high profits and poor site management, are the top ten factors of time overrun in Ghana, **Danso and Antwi ,2012. Doloi et al., 2012,** mentioned that the "poor site coordination, inefficient site management, lack of commitment, improper planning, lack of clarity in project scope, lack of communication, substandard contract, architects' reluctance for change and rework, poor labor productivity, slow decision from owner" were the main causes of time overrun in India. **Sweis et al., 2008**, investigated time overrun issue in Jordan , and found that " poor planning and scheduling, financial difficulties faced by the contractor, incompetent technical staff assigned to the project, shortage of manpower and too many change orders from owner , **Sanni and Hashim ,2013**., investigated the construction projects in Nigeria , They found that the major factors of time overrun are unstable market condition, engagement of inexperienced staff, improper contract document, complexity of the project, lack of research and innovation, choice of procurement method and unstable government regulations ".

4. DELAY

Delay means the failure to complete project in the budgeted cost & targeted time as agreed in contract. Delay occurrence is may concurrently with other delays and all of them will impact the project completion date. Many projects are experience extensive delays thereby exceed initial time and cost estimates. Construction delay considered to be one of the adverse events in the construction industry, it has an adverse effect on the project success in terms of quality, cost and time. The delays are always very expensive to all parties in projects, it will result in slows the growth of construction sector, claims, total desertion, much difficult for feasibility and clash. Delays and cost overruns reduce the available economic resources efficiency, reduce competitiveness of the economy and limit the growth potential, Singh **R., 2010**. Rearrangement, rescheduling and cost overrun, arbitration, disputes and litigation, were the main delay factors as sited by **Mohamad M. R. ,2010. Kaming et al.,1997**, exploited questionnaire survey for delay factors in Indonesian high-rise construction projects , they found that "inadequate planning, poor labor productivity, design changes, inaccuracy of materials estimate and materials shortage are the first five causes of delays". **Koushki et al. ,2005,** identified estimates of the factors of time delays, the three main causes of delays are owners’ lack of experience, owners’ financial constraints, and changing orders. a factors like "lack of proper co-ordination, delay due to subcontractors, inadequate planning, poor administration, poor communication, shortage of technical staff and deficiency in construction activities may affect the project. Considering these factors, the main causes of construction delays of projects in the developing world. **Table 1.** reviews the delay factors extracted from some studies.

5. SCOPE CREEP

Poor scope management and control was a very common reason for projects failure. the leading cause of project failure is Scope Creep , according to 2010 Global Survey, "the top 10 Obstacles of Project Success", It is very common in project management to get a scope changes, **Winch ,2002,** stated that "the scope identifies the core requirements of services, and any additionally desirable services and any constraints upon service delivery as regulatory requirements, or latest date for availability, is scope creep , it mean “the project work gradual expansion without any acknowledgement or formal acceptance of their associated schedule impacts, costs or other effects.” Also ,it is “process of adding work and requirements, step by step, till the final project completely different from the original one and the schedule and original cost estimates have become unworkable s and meaningless, and Also , refers to the scope change that happens slowly and unofficially, without make any change in dates or making adjustments to the budget." . **The Project Management Institute, 2008** , defined scope creep as adding functionality and features without addressing the resources, costs, and time effects. This occurs when the scope is poorly controlled, documented and/or defined. It is risk is that the project drifts further far away from its initial objectives and leading to higher costs and delays. In particular, misinterpretations and misunderstandings between stakeholders on facility design have significant impact on the construction ,**Knight and Fayek, 2002.** .**Bresnen and Haslam ,1991**, reported that 40% of projects having budget overruns was due to scope creep or design variations. Clients often don't fully understand their requirements at project start. The iterative process used to determine their needs requires that the project requirements be changed, which allows the client to achieve what they want exactly, this, in turn, lead to increased client satisfaction with the project results, that change process is called "creep.". Scope creep may cause by the internal and external changes, including:

1- Platform changes (e.g. car or truck)
2- Environment changes.
3- Customer requirement changes.
4- poor understanding of the customer requirements prior to the project scope definition & contract signing, **Abramovid, 2000.** The scope creep is may cause by Misinterpretation of what is contained in project Statement of Work, contract, or scope, this misinterpretation may be caused by:
1- Wide variation in task size
2- Mixing special instructions, specs, approvals, and tasks
3- Wide variation in work description details
4- No chronological, structure or pattern order
5- Using imprecise language ("approximately", "optimum", "nearly", etc.)
6- Failing to get third party review, **Harold Kerzner, 2009.** Scope creep can be because of: weak Project Manager, poorly described project objectives, poor change control, triggering of risks, bad communication, etc.

6. RESEARCH METHODOLOGY

After determining the research problem, a study of a number of data governmental projects was done, in addition to field visits to part of these projects to stand on the implementation of these projects actually, and hold direct meetings with department managers directly involved in the implementation of and contracting of the projects, The research sample consist of a heads of departments in addition to 33 engineer has a wide experience to the implementation of government projects in general and governorate projects particularly . Questionnaire consists of two parts, the first information about the sample and the second part included factors relating to the results above in addition to the factors that have been extracted from the literature and the factors that have been obtained from the direct meetings and a study of projects data. Three rounds of Delphi method were used, in each round the respondents have been asked to determine the most influential factor on the (cost overrun, time overrun, delay and change or creep the scope) , with a scale consists of four degrees of importance (most important: 1 and unimportant: 4) .

6.1 Respondents Background: The sample included a number of head of departments, project managers and engineers who have an experience in the area of government construction sector**, Table 2.** Show the Respondents Background.

6.2 Identification of Influential Factors

6.2.1 Cost overrun factors: these factors lead to a cost overrun in the project, that the allocated budget of the project will be insufficient, **Table 3** shows the cost overrun factors.

6.2.2 Time overrun factors: it's the factors that lead to make an extension un the project deadline, which mean additional cost, additional administrative work and delay in the province of services to the building users **, Table 4** shows the cost time factors.

6.2.3 Delay factors: these factors are the factors that lead to delay in all its type , material delay , time delay , payment delay etc**. Table 5** shows the delay factors.

6.2.4 Scope creep factors: here, the factors will affect all the above problems (cost overrun, time overrun and delay)**, Table 6** shows the scope creep factors.

6.2 Analysis of the Results

The most influential factors on the main results (cost overrun, time overrun, delay and change or creep the scope),(in each round , factor that gets a mean of (3) or more is one of the most influential factors, **Divakar,2009**, take mean of 2.5 from 4 point scale (0.625) ,while **Ayob,2013.,** take mean of 4 from 5 point scale (0.8) , in this study the ratio was (0.6) which mean get a best result) were obtained through the third round as follows ,

1. Cost overrun: The most influential factor on cost overrun, are shown in **Table 7.**

2. Time overrun: The most influential factor on time overrun, are shown in **Table 8.**

3. Delay: The most influential factor on delay, are shown in **Table 9.**

4. Scope creep: The most influential factor on scope creep, are shown in **Table 10.**

7. CONCLUSION

1- Through the study of projects and direct meetings with a number of heads of departments and data engineers, Show that there is a weakness and a clear imbalance in project management and in scientific knowledge in this area and lack of its practicality.

2- despite the significant benefits gained by any organization through the application of the principles and the basics of construction project management.

3- Search results also showed that there are factors that have an effective impact on the performance of projects, which require attention, planning and control in order to prevent the failure of projects .

4- There are factors that have a common effect on the failure of the project in general and on a clear defect in particular areas.

5- Results show that the most of the factors were a managerial factors, thus, it could be controlled and minimized by improve the managerial skills in the construction organizations by conducting workshops and proper trainings.

8. RECOMMENDATION

In order to get successful projects has to be attention to the the following:

1- The use of the principles and the basics of project management construction in addition to the full knowledge of all the requirements.

2- Attention to training and development for all individuals working in governmental organizations.

3- Ensure existence of an efficient comprehensive administrative system for monitoring, follow-up and controlling of projects in addition to build an extensive and comprehensive database for all projects data.

4- Pay attention to the external circumstances surrounding project implementation to take advantage of the positive aspects and to prevent or minimize the negative effects on projects .

5- Attention to the feasibility studies in addition to the full identification of all project users' requirements in general and the project in particular.

6- Contracting with companies sober for design and engineering consultancy.

7- Attention to the issue of classification of contractors to contract with reputable and high-efficiency companies.

8- Attention to planning, scheduling, follow-up, control and monitoring of work in all phases of the project.

9- Attention to operating and maintenance cost and attention to it to reduce the operating costs.

10- Planning and ongoing communication with all government departments to coordinate with them in the implementation of projects.

11- Ensure that there is adequate funding and optimal use of resources at the stage of feasibility studies in order to prevent obstruction of work on the project later.

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Table 1. Delay factors.

Item	Study	Delay Factors
1	**Assaf et al., 1995**	-Slow preparation and approval of shop drawings -Delays in payments to contractors -Changes in design/design error -Shortage of labor supply -Poor workmanship
2	**Kaming et al. ,1997**	-design changes -inadequate planning, -Productivity, -poor labor -Resource shortages.
3	**Al-Momani.,2000**	-weather -user changes - factors related to designer -economic conditions -late deliveries, -site conditions -increase in quantity.
4	**Assaf and Al-Hejji, 2006**	-Ineffective planning and scheduling -Delay in progress payment -Change orders -Shortage of labor -Contractor difficulties in financing
5	**Tommy et al.,2006**	-Client variation -Inadequate contractor resources - Unforeseen ground conditions -Poor site management and supervision -slow co-ordination and seeking of approval -Inexperienced contractor
6	**Sweis et al.,2007**	-contractor Poor planning and scheduling -Shortage of manpower -Contractor financial difficulties -Too many change orders by the owner
7	**Saleh et al., 2009.**	-Slow decision making -Financial issues -Shortage of supply -Shortage of material -Improper planning -Lack of effective communication -Design errors
8	**Wei K. S. 2010.**	-change orders by owner during construction -Delays in sub-contractors work -Poor communication and coordination -Late in revising and approving design documents

Table 2. Respondent's background.

Respondents	Frequency (percentage) %
Gender	
Male	80
Female	20
	100
Type of respondents position	
1. Project Manager	34
2. Architecture	21
3. Engineer	15
4. Consultant	12
5. department manager	18
Educational attainment	
B.Sc.	66.5
High diploma	21
M.Sc.	9
Ph.D.	3.5
Working experience	
6-10 years	15
11-15 years	30
16-20 years	25
Above 20 years	30
Engineering Specialization	
Civil	51.5
Mechanic	18
Electric	18
Architectural	12.5

Table 3. Respondents' answers on cost overrun factors.

Item	Cost overrun factors	Importance degree (%)			
		1	2	3	4
1	Shortage of manpower	2.5	23.5	40	31
2	Change orders by client	23	39	26	12
3	Inaccurate quantity	6.5	13	46.5	31
4	Increase in labor cost	0	15.5	44.5	36.5
5	Project complexity	4	19	43	29
6	Client’s late contract award	13	22	33	26
7	Shortage of skilled labor	5.5	28	33.5	23.5
8	Inaccurate material estimates	7.5	29.5	34.5	26
9	Increase in material cost	29.5	37	9.5	21
10	incapable inspectors	4	25	29.5	34.5
11	late design works	7.5	25.5	27	33.5
12	late approval	31.5	25.5	19	10
13	late inspection	14	28	31	27
14	inappropriate design	19	18	32	31
15		30	15.5	42.5	5.5

	design changes				
16	changes in management ways	6.5	30.5	40	17
17	high competition in bids	11.5	27	39	21
18	late issuing of approval documents	6.5	23.5	40	27
19	postponement of project	8	21.5	42	25.5
20	late submission of nominated materials	6	35	36	14
21	late documentation	17	35	27.5	11
22	delay in commencement	7.5	27.5	27.5	29
23	late land hand-over	8	31.5	30.5	29
24	resource management	15	29	31	21
25	undefined scope of working	12	35	32.5	18
26	internal administrative problems	30.5	38	10.5	19
27	unreasonable project cost frame	12	21.5	36	25
28	delays in decision making	32.5	15.5	42.5	7.5
29	poor communication between parties	15	23	38	24
30	Incomplete drawings	22	30	19	29
31	lack of equipment efficiency	24	21	24	31
32	rework from poor workmanship	19	16	31	34
33	natural disaster	11	34	32	23
34	weather condition	21	21	31	27
35	Inflation	19	32	24	25
36	stoppages	24	34	25	17
37	exchange rate fluctuation	17	14	42	27
38	financial status of owner	31	45	17	7
39	financial status of contractor	38	40	5	17
40	payments delay	41	38	9	12

Table 4. Respondents' answers on time overrun factors.

Item	Time overrun factors	Importance degree (%)			
		1	2	3	4
1	Unforeseen site conditions	14	21	34	31
2	Failure of equipment	12	16	38	34
3	Materials price regulations	11	24	42	23
4	Interference by owner in construction operation	11	21	31	37
5	Shortage of materials	19	12	44	25
6	Shortage of equipment	24	17	25	34
7	Slow response by the consultants	35	39	9	17
8	Financial constraints faced by owner	26	45	7	22
9	Incompetent technical staff	11	27	39	21
10	Difficulties in obtaining work permits	11	22	40	27
11	Poor qualification of consultants	11	22	38	31
12	Poor planning and scheduling	41	17	20	22
13	Improper technical study by the contractor	21	14	42	23
14	Delay in the approval of contractor submissions	25	44	12	19
15	Shortage of technical professionals in the	17	21	21	41

	contracting organization				
16	Slow decision making from owner	10	27	28	35
17	Delays in contractors claims settlements	11	39	22	28
18	Delays by the contractor payments to subcontractors	8	37	21	34
19	Ineffective quality control by the contractor	9	28	51	12
20	Modification in material specifications	12	21	22	45
21	Shortage of manpower	6	15	42	35
22	Laws and Regulatory Framework	22	30	33	15
23	Lack of communication between parties	22	27	29	22
24	Lack of coordination between parties	10	27	28	35
25	Accidents on site	11	39	22	28
26	Unforeseen ground condition	30	9	23	38
27	Effect of weather	18	35	23	24
28	Shortage of site workers	9	29	29	33
29	labor productivity	21	17	21	41
30	External conditions affecting the project	41	38	12	9
31	Insufficient Numbers of equipment	10	27	38	25
32	Late delivery of materials and equipment	11	22	39	28
33	Fluctuation of prices of materials	38	30	22	10
34	Mistakes during construction	24	45	22	9
35	Incompetent subcontractors	38	28	22	12
36	Poor site management and supervision	10	17	38	35
37	Lack of experience	44	30	4	22
38	Incomplete design at the time of tender	10	27	28	35
39	Delay Preparation and approval of drawings	11	39	22	28
40	Mistakes and Errors in design	33	45	8	14
41	Frequent design changes	14	23	36	25.5
42	Unrealistic contract duration and requirements	14	25	30.5	25
43	Delay in inspection and approval of completed work	4.5	25	33	31.5
44	Delay in materials delivery	18	25.5	31.5	25

Table 5. Respondents' answers on Delay factors.

Item	**Delay factors**	**Importance degree (%)**			
		1	**2**	**3**	**4**
	Owner Related Delay Factors				
1	Lack in experience	3	22	35	20
2	Misunderstandings in technical dealing with vendors & contractors	12	27	46	17
3	Suspension of work due to owner	4	33	41	22
4	Coordination between the parties is not appropriate work	20	38	8	34
5	Lack of communication & co-ordination	11	34	25	30
6	delays in payments of completed work	15	45	25	15
7	changes by owner during construction	19	44	17	20

8	Late revising & approving relevant documents by owner	7	32	37	24
	Consultant Related Delay Factors				
9	Inadequate site information given to consultant	10	27	28	35
10	Conflicts of consultant with design engineer	11	39	22	28
11	Complexity of project design faced by consultant	8	37	21	34
12	Communication barriers faced by consultant	9	28	51	12
13	Difficulties in receiving payments from agencies faced by consultant	12	21	22	45
14	Conflicts between consultant & contractor	6	15	42	35
15	Delay in handover of site to contractor	15	24	19	42
16	changes in specification during construction by consultant	6	41	29	24
17	Inflexibility of consultant	12	26	33	29
	Contractor Related Delay Factors				
18	Lack of experience of contractor	25	31	32	12
19	Contractor’s slowness in preparation of documents & material samples	9.5	37	29.5	21
20	Poor managerial skills in contractor	4	25	29.5	34.5
21	Poor understanding of accounting & financing project	7.5	25.5	27	33.5
22	Compatibility of contractor with new software’s	10	25.5	19	31.5
23	Is contractor compatible with new technology	13	23.5	32.5	28
24	Rework in construction faced by contractor	9.5	37	29.5	21
25	Conflicts with sub-contractor	4	25	29.5	34.5
26	Contractor’s Poor site management & supervision	35	24	27	14
27	Contractor’s slowness in site mobilization	14	23	36	25
28	Contractor’s inadequate planning & scheduling	14	25	30.5	25
29	Material Related Delay Factors				
30	Untimely delivery	3	2.5	23.5	40
31	Materials not in right place when needed	2.5	12	23.5	39
32	Escalation of material prices	3	6.5	13	46.5
33	Material damage in storage	3.5	0	15.5	44.5
34	Poor Material management	5	4	19	43
35	Slow process of material selection	6	13	22	33
36	Changes in quality of material	9.5	5.5	28	33.5
37	Frequently unexpected modifications in specification of material during construction	2.5	7.5	30	34
38	Contractor Financial difficulties	30	35	25	10
	Project Related Delay Factors				
39	Accidents on site	14	23	36	25.5
40	Inaccurate cost estimates	14	25	30.5	25
41	Changes in site topography after design	4.5	25	33	31.5
42	Insufficient data collections & survey	11.5	25.5	31.5	25
43	Unforeseen ground conditions	20	15.5	30.5	29.5

44	Changes in site conditions	15.5	17	28	19.5
45	The security situation economic and political	45	35	12	8
46	External Related Delay Factors	12	13	33	42
47	Changes in government regulation & laws	7	14	42	37
48	The diversity of projects implemented	12	48	30	10
49	Weakness in experience of project manager and his team	22	50	21	7

Table 6. Respondents' answers on scope creep factors.

Item	Scope creep factors	Importance degree (%)			
		1	2	3	4
1	Involving the users only in later stages	3	2.5	23.5	40
2	Management failure in managing user expectations	2.5	12	23.5	39
3	Underestimating the complexity of the problem	3	6.5	13	46.5
4	Insufficient Requirements Analysis	3.5	0	15.5	44.5
5	Modification of rules	5	4	19	43
6	Uncertainty in technology	6	13	22	33
7	No recognition of interfacing processes	9.5	5.5	28	33.5
8	Inaccurately defined processes	2.5	7.5	29.5	34.5
9	Client/user disagreement	8	38	22	32
10	Stakeholder multiplicity	27	41	22	10
11	Change in market conditions	32	29	34	5
12	Feature creep	12	39	27	22
13	Flexibility	9	24	32	35
14	Interfaces not defined	10	39	34	17
15	Bad relation with client	7	14	51	28
16	Not enough time to understand client’s needs	35	46	17	2
17	No stakeholder involvement	41	35	13	11
18	Wrong people defining scope	47	31	25	7
19	Ambiguous requirements	14	27	35	24
20	Requirements not clearly defined	9	33	41	17
21	Learning	12	25	29	34
22	Conflict in different government agencies interests	17	31	35	17
23	absence of scope management and control	22	39	32	7
24	Bad management of project changes	14	45	22	19
25	data was not enough to define the scope	10	29	30	31
26	Intervention by Government officials and politicians	7	31	47	15
27	Delay in project execution	22	29	37	12
28	Ignorance of key stakeholders	12	35	13	40

Table 7. The most influential Cost overrun factors.

Item	Cost overrun factor	mean	SD	rank
1	payments delay	3.74	1.025	1
2	financial status of contractor	3.67	.879	2
3	financial status of owner	3.51	.654	3
4	internal administrative problems	3.49	.971	4
5	design changes	3.42	.612	5
6	Increase in material cost	3.38	1.154	6
7	Change orders by client	3.2	1.023	7
8	late approval	3.15	1.087	8
9	delays in decision making	3.12	.754	9
10	Stoppages	3.04	.915	10

Table 8. The most influential time overruns factors.

Item	Time overrun factor	mean	SD	rank
1	External conditions affecting the project	3.84	0.874	1
2	Mistakes and Errors in design	3.67	0.987	2
3	Lack of experience	3.61	1.023	3
4	Incompetent subcontractors	3.54	1.412	4
5	Mistakes during construction	3.5	1.023	5
6	Fluctuation of prices of materials	3.48	0.871	6
7	Slow response by the consultants	3.3	0.612	7
8	Financial constraints faced by owner	3.25	1.067	8
9	Poor planning and scheduling	3.22	0.624	9
10	Delay in the approval of contractor submissions	3.17	1.029	10
11	Laws and Regulatory Framework	3.08	1.011	11
12	Lack of communication between parties	3.08	1.049	12
13	Unforeseen ground condition	3.03	0.698	13

Table 9. The most influential delay factors.

Item	Delay factor	mean	SD	rank
1	The security ,economic and political situation	3.50	1.022	1
2	Contractor's Poor site management & supervision	3.39	0.790	2
3	Contractor Financial difficulties	3.27	1.134	3
4	changes by owner during construction	3.24	0.767	4
5	delays in payments of completed work	3.2	0.785	5
6	Lack of experience of contractor	3.17	0.887	6
7	Inaccurate cost estimates	3.12	.845	7
8	Weakness in the experience of the project manager and his team	3.09	1.060	8
9	Coordination between the parties is not appropriate work	3.06	.712	9
10	The diversity of projects implemented	3.04	1.060	10

Table 10. The most influential scope creep factors.

Item	Scope creep factor	mean	SD	rank
1	Wrong people defining scope	3.69	0.790	1
2	No stakeholder involvement	3.66	1.134	2
3	Not enough time to understand client's needs	3.57	0.767	3
4	Change in market conditions	3.48	0.848	4
5	Stakeholder multiplicity	3.3	0.678	5
6	Conflict in different government agencies interests	3.22	0.581	6
7	Delay in project execution	3.18	1.060	7
8	absence of scope management and control	3.1	1.119	8
9	Bad management of project changes	3.03	0.741	9

Table 11. The most influential factors on the Stumble and Failure, its weight and rank.

Item	Factors	Factors group	Weight %	ran k
1	External conditions affecting the project	all	16.4	1
2	Financial constraints faced by owner	All	12.4	2
3	financial status of contractor	All	12.08	3
4	The diversity of projects implemented	All	10.4	4
5	Lack of communication between parties	All	9.7	5
6	design changes	All	8.5	6
7	Contractor's Poor site management and supervision	All	8.3	7
8	delays in payments of completed work	All	8.27	8
9	Lack of experience of contractor	All	7	9
10	delays in decision making	All	7	10
11	Slow response by the consultants	All		11

Removal of Fluoride Ions from Wastewater Using Green and Blue-green Algae Biomass in a Fluidized Bed System

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ABSTRACT

The removal of fluoride ions from aqueous solution onto algal biomass as biosorbent in batch and continuous fluidized bed systems was studied. Batch system was used to study the effects of process parameters such as, pH (2-3.5), influent fluoride ions concentration (10- 50 mg/l), algal biomass dose (0–1.5 g/ 200 ml solution), to determine the best operating conditions. These conditions were pH=2.5, influent fluoride ions concentration= 10 mg/l, and algal biomass dose=3.5 mg/l. While, in continuous fluidized bed system, different operating conditions were used; flow rate (0.667- 0.800 l/min), bed depth (8-15 cm) corresponded to bed weight of (80- 150 g). The results show that the breakthrough time increases with the increase of bed depth but decreases with the increase of flow rate. Thomas and Yoon-Nelson models were used to analyze the experimental data and there was a good matching between the theoretical and the experimental data for both models. Desorption studies indicate that NaOH solutions at different pH values (8-10) were used to recover the fluoride ions sorbed onto the algal biomass. It is noteworthy that the desorption efficiency at pH =10 remains close to 95 % of the initial value of sorption capacity. So the desorption performance remains appreciable.

Keywords: Fluoride ions Fluidized bed, algal biomass, Thomas and Yoon-Nelson models.

أزالة ايونات الفلورمن مياه الفضلات بأستخدام كتلة الطحالب الخضراء والزرقاء في نظام انبوب التميع

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تتناول هذه الدراسة استخدام الطحالب كمادة مازة لإزالة أيونات الفلور من محلول مائي في نظامي دفع متقطع ومستمر بأستخدام انبوب تميع. في نظام الدفع المتقطع تمت دراسة تأثير عدة معاملات مثل الرقم الهيدروجيني (3.5-2)، تركيز ايونات الفلو (10- 50 ملغ / لتر)، كمية المادة المازة (0-10 غرام / 200 مل من المحلول)،ووجد بأن افضل ظروف تشغيلية هي الرقم الهيدروجيني=2.5 ، تركيز ايونات الفلور=10 ملغ/لتر،

كمية المادة المازة=3.5 غم/لتر. بينما في نظام انبوب التميع المستمر تم استخدام ظروف تشغيلية مختلفة حيث ان معدل الجريان (0.667- 0.800لتر / دقيقة)، وارتفاع الحشوة (8- 15 سم) وبوزن(80 - 150 غ) على التوالي. توضح هذه النتائج أن زمن الإختراق يزيد مع زيادة عمق الحشوة ولكن يتناقص مع زيادة معدل التدفق. تم استخدام موديلي ثوماس ويون ونيلسون لتحليل النتائج المختبرية وكان هناك توافق بين النتائج النظرية والعملية لكلا الموديلين. أما دراسة عكس الامتزاز تشير الى استخدام محلول NaOH ولقيم مختلفة من الرقم الهيدروجيني (9-10) لاستخلاص الفلور الممتز على الطحالب. ومن الملاحظ ان الحصول على افضل عكس الامتزاز وبكفاءة 95% يحصل عندما تكون قيمة الرقم الهيدروجيني= 10.

الكلمات الرئيسية: ايونات الفلور، انبوب التميع، كتلة الطحالب، موديل ثوماس وموديل يون- نيلسون

1. INTRODUCTION

Fluoride is a ubiquitous element present in earth's crust. It belongs to group 17 of the Periodic Table and it is the most electronegative of all elements. Fluoride is considered as valuable and extensively used in industry such as toothpastes, fertilizers, production of graphite, semiconductors, electrolysis of alumina ,**Tripathy et al., 2006.** Large quantities of wastewater, which contains high concentrations of fluoride and its compounds, are generated from these activities. Fluoride may enters food chains and reaches to the human through either drinking water or eating plants and cereals. Fluoride has gained importance due to its dual influences on human beings. When present within the permissible limit, fluoride is an essential nutrient for the calcification of dental enamel and maintenance of healthy bones, so that it is purposely added to drinking water in small quantities to prevent dental caries. But the high concentration of fluoride is a serious hazard to human health and may causes fluorosis, brittle of bones, curvature of bones, dwarfishness, mental derangements, cancer, and in extreme cases even death. The permissible limit of fluoride in drinking water is 1 mg/l as recommended by WHO standards , **Meenakshi, 2006**. Pollution by fluoride has been observed in some natural water systems in Asia, Africa, America, and Europe, where the fluoride concentration can range from 0.01 to 3 mg/l in fresh water and 1 to 35 mg/l in ground water , **Rajiv Gandhi, 1993**. Due to high toxicity of fluoride to mankind, there is an urgent need to search for advanced wastewater treatment mechanisms to treat fluoride-contaminated water and to make it safe for human consumption. As a result, numerous efforts have been undertaken to find effective and low cost methods to remove fluoride from waste solutions.

Available treatments process for Fluoride from water and wastewater include chemical precipitation (by alum, lime, lime and alum and calcium chloride), adsorption (by activated alumina, clay and flay ash), ion exchange (by synthetic resins) and membrane technologies (by reverse osmosis and electro-dialysis). These methods require more technical support for operation and maintenance and the capital investment cost is very high ,**Mann and Mandal, 2014**. This is an obvious constraint on the use of these methods in certain applications, especially for fluoride removal from wastewater. Alternatively, the so-called biosorption, i.e., the property of certain dead biomass to bind and concentrate selected ions or other molecules from aqueous solution, could be considered. Biosorption by dead biomass is passive and based mainly on the affinity between the biosorbent and sorbate ,**Volesky, 2007; Sulaymon et al., 2012**. Different materials have been reported in the literature as inexpensive sorbents for fluoride removal; for example, crashed limestone **, Nath and Dutta, 2010.** Alum- , **Tripathy et al., 2006**. Rice husk ,**Vardhan and Karthikeyan, 2011**. Moreover, **Sulaymon et al., 2013a.** mentioned that biosorption by algae is proven to be quite effective at removing metal ions from contaminated solutions in a low-cost and environment-friendly manner. This can be attributed to the abandons of algal biomass and it has many negative charge active groups on its surface cell wall such as hydroxyl, carboxyl, amino, sulfhydryl, and sulfonate. These groups were part of the algal cell wall structural polymers, namely, polysaccharides (alginic acid, sulfated polysaccharides), proteins, and peptidoglycans. Although much of the current biosorption researches using algae are oriented towards the removal of metal cations, the binding of anions like fluoride to this biomass is a growing area of study. As well as, a few studies were carried out in continuous system using fluidized bed applications.

For evaluating the feasibility and effectiveness of biosorption in wastewater treatment it is essential to make predictions of the sorption performance, e.g. for facilitating process design. Therefore it is important to develop appropriate mathematical models of biosorption binding equilibrium and dynamic which are necessary as a prerequisite for all further work involving; batch, and column applications.

This work investigates the removal of fluoride in a fluidized-bed reactor of algal biomass as biosorbent. The preparation, characterization and sorption properties of biosorbent were reported. Moreover, the effect of some experimental conditions on the fluoride removal such as superficial velocity and bed height was evaluated and to model the process using a well-known empirical models.

2. MATERIALS AND METHODS

2.1 Materials

2.1.1Collection of Biosorbent Material

Fresh samples of green and blue-green algae were used in this study as a biosorbent. This material was collected from the artificial irrigation canal in Baghdad University, Iraq. It was mainly combined of three species of algae. Blue-green Oscillatoria princeps alga was the highest percentage (88%), green Spirogyra aequinoctialis alga was (9%), and blue-green Oscillatoria subbrevis alga (3%). And to make it used friendly the collected algae were not separated. The foreign matters were removed manually from the collected algae, then rinsed with tap and distilled water to remove dirt, sands, and external salts. Afterward, the washed algae were kept in air for evaporating of water and dried in an oven at 65 °C for 48 h. The dried biomass were roughly chopped, grounded into powder, sieved, and kept in air-tight polyethylene container at room temperature. An average size of 0.55 mm was used for biosorption experiments with required amounts.

2.1.2 Fluoride Solution

All the chemicals used in this study were of analytical grade, and deionized water was used for solution preparation. A stock solution (1000 mg/l) of fluoride ions was prepared by dissolving appropriate amount of sodium fluoride (provided by Merck, Germany) in distilled water and stored in glass container at room temperature. The working fluoride ions solutions were prepared by appropriate dilution in accurate proportions of the stock solution immediately prior to use. The pH of the working solution was adjusted by using dilute HCl or NaOH solutions using a pH meter (type WTW, InoLab 720, Germany). Prior the experiments, all the glassware used for dilution, storage, and experimentation were cleaned with detergent, thoroughly rinsed with tap water, soaked overnight in a 20% HNO_3 solution, and finally rinsed with distilled water before use.

2.2Methods

2.2.1 Batch System Experiments

Experimental parameters affecting the biosorption process such as pH (2-3.5), precipitant dose (0-1.5 g/ 200 ml solution), and initial fluoride ions concentrations (0-50 mg/l) were studied in batch system. The experiments were conducted in 250 ml stoppered conical flasks containing 100 ml of pre-determined fluoride ions aqueous solution (1–50 mg/l) and 1 g of algae, under constant shaking at room temperature (20 ± 3°C). The pH solution was adjusted to the desired value. The flasks were placed in a shaker (Edmund Buhler, 7400 Tubingen Shaker-SM 25, Germany) under constant shaking speed (200 rpm) for 3 h. After equilibrium biosorption, the sorbent was separated from aqueous solution by using filter paper (Whatman, No.42, diameter 7 cm) and the residual concentration of fluoride was measured. The concentration of fluoride in both initial and withdrawn samples was determined using Orion Multiparameter Kit Ion Meter. The instrument was calibrated each time the analysis was done. All the samples were measured in triplicate and the average value was obtained. The fluoride removal was calculated by using the following equation:

$$\text{Fluoride removal} = \left(\frac{C_o - C_e}{C_o}\right) \quad \dots\dots\dots\dots\dots..(1)$$

Where, C_o and C_e are the initial and equilibrium fluoride concentrations in water (mg/l), respectively.

2.2.2. Continuous system experiments

A fluidized bed reactor which is shown in **Fig. 1** was designed to investigate the algal biomass biosorption efficiency for fluoride ions. The fluidized bed reactor is a 7.5 cm inner diameter and 1 m high glass column. In order to homogenize and evenly distribute the liquid flow before it reaches the algal biomass bed section, the column consists of a calming entry section of length of 5 cm filled with glass beads of mean radius 2 mm and covered with stainless steel sieve. In addition, the fluidized bed reactor has a screen at the bottom to support the algal biomass particles and at the top to remove the presence of particles in the effluent. A 10 W lamp was installed behind the reactor to measure the expanded height of algal biomass bed accurately. The fluoride solution of 10 mg/l was pumped into the reactor vertically and fluidized the algal biomass bed at a flow rate of 40 l/h with the temperature kept at room temperature, that is, about 25±3 °C. The solution pH was adjusted to a desired value by using 0.1N NaOH / HNO_3. Samples were periodically taken from the effluent of the reactor at different time intervals and analyzed for fluoride concentration. The operation of the column was stopped when the outlet fluoride ion concentration reached its initial concentration.

The experimental sorption capacity can be obtained using equation 2; it is calculated from the area above the breakthrough curve, taking into account the volume of treated water through the column and the mass of biosorbent, used in the packed column.

$$q_{exp} = \int_0^{V_{total}} \frac{(C_0 - C_t)}{m} dV \quad \dots\dots\dots\dots\dots (2)$$

Where, q_{exp} is the sorption capacity (mg/g); C_t is the withdrawn fluoride concentration (mg/l); m is the mass of the algal biomass (g), V (l) is the volume of treated water (**Meenakshi, 2006**).

2.2.3 Breakthrough Curves Models

There are many dynamic models for describing the performance of column systems. Thomas model is widely used for its simplicity and for its adequate accuracy in predicting breakthrough curves under various operating conditions. The model is represented by the following equation (**Yilmaz-Ipek, 2013**):

$$\frac{C}{C_0} = \frac{1}{1 + \exp\left[\frac{K_T(q_T m - C_0 V)}{Q}\right]} \quad \dots\dots\dots\dots\dots. (3)$$

Where, K_T is the Thomas rate constant (l/min.mg), m is the mass of sorbent (g), Q is the volumetric flow rate (l/min), C is the sorbate concentration and q_T is the Thomas sorption capacity (mg/g).

The Yoon-Nelson model is a simple model for describing the sorption and breakthrough curves of the sorbate. It requires no detailed data on the characteristics of the sorbate, the type of sorbent, or the physical properties of the sorption bed, and is expressed as follows (**Yilmaz-Ipek, 2013**):

$$\frac{C}{C_o} = \frac{\exp(K_{YN}t - \tau K_{YN})}{1 + \exp(K_{YN}t - \tau K_{YN})} \quad \dots\dots\dots\dots\dots... (4)$$

Where τ is the time required for 50% sorbate breakthrough (min) when fluoride concentration C (mg/L) is one half of C_o, and K_{YN} is the rate constant.

2.2.4 Desorption

When the relative concentration (*C/Co*) achieved a value near about 1, the adsorption process become saturated and regeneration process was start to wash out the loaded metal ions from the pores of the adsorbent. Desorption is a very important concern to reuse the biosorbent and reduce process costs. It is desired that the adsorbent should be close to its original form, and should not lost its sorption ability after desorption. In addition, the recovery of valuable metals from dilute aqueous wastes is a complementary process. For this case, acidic or basic solutions are frequently used for desorption of metal ions sorbed on different sorbents (**Sezen et al., 2012**).

3. RESULTS AND DISCUSSIONS

3.1Characterization of the Algal Biomass

A sample of powdered algal biomass was analyzed for surface characterization such as surface area and porosity. **Table 1** listed the physicochemical properties of the algal biomass used in this study. The surface area of algal biomass was determined from nitrogen adsorption-desorption isotherm analysis using a Micrometrics Nano Porosity System.

It can be seen that the surface area and the pore volume of the biosorbent were 4.07 m^2/g and 0.713 cm^3/g, respectively. These values are small compared with those of other materials like activated carbon, so that the removal efficiency is very sensitive to the porous sorption. In this case it is recommended to use fluidized bed reactor rather than fixed bed system.

3.2 Parameters Affect Biosorption

Fig. 2 depicts the fluoride ions removal as a function of algal biomass dosage for different initial concentrations. Clearly, the fluoride ions removal increased with the increase of algal biomass dose from 0.01 to 0.7 mg/200 ml solution and thus the biosorbent dose was an important factor to the fluoride ions removal. The reason being that; an increase in the sorbent quantity in the aqueous solution results in a larger exchangeable area for fluoride ions biosorption. This figure also shows that the removal rate of fluoride ions considerably remains stable at algal biomass dosages beyond 0.7 g/200 ml aqueous solution, implying that the best amount of algal biomass is 3.5 g/l solution for all initial fluoride ions concentration values. Therefore, this dose is used in all subsequent experiments. Moreover, experimental results revealed that the highest fluoride ions removals were 0.93, 0.88, and 0.68 at initial concentrations of 10, 20, and 50 mg/l, respectively. By increasing the initial concentration from 10 to 20 mg/l the removal efficiency does not alter greatly. This is probably can be inferred due to the fact that the amount of algal biomass used in this experiment contains enough sorption active groups and sites for the binding of fluoride ions. When the initial concentration increased to 50 mg/l the removal of fluoride ions was significantly affected. This can be attributed to the increase in the fluoride ions concentration provides a greater driving force to overcome the mass transfer resistance through particles as well as the collision between fluoride ions and algal biomass particles is enhanced at higher concentrations as stated by , **Hekmatzadeh et al., 2013**. However, increasing the initial fluoride ions concentration led to a drop in the removal of it as shown in **Fig. 2**.

The most important factor affecting the sorption of ions is the pH of the aqueous solution. According to , **Cengeloglu, 2002.** the removal of fluoride ions is highly efficient under low pH values this is due to positive charge ions (H^+) density on the sites of biomass surface will enhance metal anion sorption. Hence, the pH was initially adjusted between 2 and 3.5 and the results are depicted in **Fig. 3**. At initial pH 3 the final pH slightly increased to 4.5. This can be explained by that untreated algae biomass generally contains light metals such as K^+, Na^+, Ca^{2+}, and Mg^{2+} which are originally present in freshwater. These ions are bound to the surface acidic functional groups and when algal biomass reacts with metal-bearing solution, releases light metal ions and pH increases, these results agreed with , **Sulaymon et al., 2013b**. This also was explained in terms of ion exchange, whereby the observed released light metals balanced the uptake of cation ions as stated by ,**Schiwer and Volesky, 1996; Kratochvil, 1997**. It is clear from **Fig. 3** that the solution pH value was an important parameter controlling the biosorption of fluoride ions onto the surface of the algae biomass. From pH 2.0 to 2.5, biosorption of fluoride ions onto algal biomass showed increasing phenomena and at pH 2.5 it attains the maximum removal. The increase in fluoride ions removal with the increase in pH is because at acidic solution, more protons will be available to protonate the active group and increasing the number of binding sites for biosorption of fluoride ions. These results agreed with **, Elwakeel, et al., 2014**.

Above pH 2.5, the biosorption of fluoride was decreased sharply. This trend can be attributed to that at pH above 2.5 the surface of algal biomass does not adequately protonated with a positive charge and fluoride ions could thus be bound. So at $pH < pH_{PZC}$ (PZC is the point of zero charge) the surface of the sorbent is positively charged, indicating a greater affinity for anions as stated by ,**Zelmanov and Semiat,**

2014. These results are in agreement with, **Roberts 1992, Kratochvil and Volesky (1998)** who pointed that for anionic metals only when the solution pH is lower than the conjugated acid dissociation constant pKa value, the active groups such as carboxylic and chitin amide groups could be effectively protonated with a positive charge and an anion metal could thus be bound. At pH below 2.5 and despite of high density of H^+ ions, the fluoride ions removal was decreased owing to the dissociation of the biosobent as stated by , **Sulaymon et al., 2014**. For the further experiments the pH solution was fixed at 2.5.

3.3 Fluidized Bed System

Breakthrough curves generally permit a good description of the processes in sorption columns. The resulting breakthrough curves at different parameters are presented in **Figs. 4-7**. The experimental biosorption capacity values of the fluidized bed reactor are shown in **Table 2**. It can be seen that Thomas and Yoon-Nelson models show a good fit with the experimental data related to R^2 values. **Figs. 4 and 5** show the breakthrough curves of algal biomass towards fluoride ions at different flow rates (0.667, 0.734, and 0.800 l/min) and an expanded bed height of 10 cm for the two models. The breakthrough generally occurred faster with higher flow rate and the slope of the breakthrough curve increased with increasing liquid flow rate. The breakthrough points (90% removal efficiency) occurred at 2, 9 and 20 min for liquid flow rate of 0.800, 0.734, and 0.667 l/min, respectively. This can be attributed to that increasing the flow velocity would decrease the contact time between the fluoride molecules and algal biomass particles along the column bed. Increasing the flow rate may be expected to make reduction of the liquid film thickness. Therefore, this will decrease the resistance to mass transfer and increase the mass transfer rate as well as there is not enough time for sorption equilibrium to be reached. In addition, decreasing the flow rate allows the solute to diffuse more efficiently in the sorbent: the mass transfer zone (where the reaction takes place) is shortened. These mechanisms are also consistent with that obtained by , **Sulaymon et al., 2010**. The maximum biosorption capacities of the fluidized bed reactor at different flow rates are 2.94, 2.53 and 2.1 mg/g for flow rate 0.667, 0.734, and 0.800 l/min, respectively.

The effect of bed depth on the sorption process was investigated at bed height of 8, 10 and 15 cm (corresponded to bed weight of 80, 100 and 150 g). Thomas and Yoon -

Nelson models were used to predict the breakthrough curves. The two models show a good fit with the experimental data and the results are depicted in **Figs. 6 and 7**. These results showed that with increasing the bed weight of the algal biomass the time at which an effluent concentration reached breakthrough point is increased, this is due to the large contact time between the fluoride ions and biomass particles at a high bed depth. Smaller bed heights will be saturated in less time. Also, an increase in the bed depth will increase the surface area for the sorption which will improve the removal efficiency. The results agree with that obtained by ,**Sulaymon, and Ebrahim, 2010**.

3.4 Desorption process

In the present study, NaOH solutions at different pH were used to recover the fluoride ions sorbed on the algal biomass. This strong base will displace the sorption equilibrium toward fluoride ions release. The desorption capacity values of the column are shown in **Table 3**. The volume of dilute NaOH solution required to recover the fluoride for each desorption cycle was fixed at 10 l. It is noteworthy that the desorption efficiency at pH equal 10 remains close to 95 % of the initial value of sorption capacity. So the desorption performance remains appreciable.

4. CONCLUSIONS

Algal biomass was used to remove fluoride ions from aqueous solution in continuous fluidized column system and it was found to be very effective adsorbent. The present work demonstrates that the operation is highly dependent on the pH, influent fluoride ions concentration, and algal biomass dose. The breakthrough time in continuous fluidized bed system was increased with the increase of bed depth but decrease with the increase of flow rate. The experimental data were well fitted to Thomas and Yoon-Nelson mathematical models. From the mathematical models it was observed that the maximum metal uptake capacity was decreased with the increase of bed depth but increased with the increase of flow rate. Desorption process shows that the algal biomass is economically suitable for the regenerate 95 % of the initial value of sorption capacity of fluoride ions at pH =10.

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Table 1. Properties of the algal biomass used in biosorption experiments.

Parameter	Value
Particle diameter (mm)	0.4-0.6
Bulk density(g/cm^3)	0.680
Real density (g/cm^3)	1.100
Surface area (m^2/g)	4.07
Micropore volume (cm^3/g)	0.713
Bed void fraction	0.577
Point of zero charge, pH_{PZC}	5.5
Total exchange capacity (mEq/g)	1.24

Table 2. Experimental and theoretical parameters in fluidized bed reactor for Fluoride removal.

Run	Experimental Parameters						Thomas model parameters			Yoon and Nelson model parameters		
	Q (l/min.)	pH	m (g)	h (cm)	C_o (mg/l)	q (mg/g)	K_T (l/min.mg)	q_T (mg/g)	R^2	K_{YN}	τ	R^2
1	0.667	2.5	100	10±0.1	10	2.940	$9.98*10^3$	2.794	0.998	0.099	41.889	0.997
2	0.734	2.5	100	12±0.1	10	2.530	$9.50*10^3$	2.400	0.998	0.095	32.987	0.998
3	0.800	2.5	100	14±0.1	10	2.100	$9.68*10^3$	1.997	0.995	0.096	24.957	0.995
4	0.667	2.5	150	15±0.1	10	2.992	$8.54*10^3$	2.88	0.999	0.085	58.073	0.999
5	0.667	2.5	80	8±0.1	10	1.52	$9.55*10^3$	2.775	0.998	0.095	33.291	0.998

Table 3.Desorption capacity values

Run	Experimental Parameters					
	Q (l/min.)	pH	m (g)	h (cm)	C_o (mg/l)	q (mg/g)
1	0.667	8	100	10±0.1	10	2.107
2	0.667	9	100	10±0.1	10	2.556
3	0.667	10	100	10±0.1	10	2.799

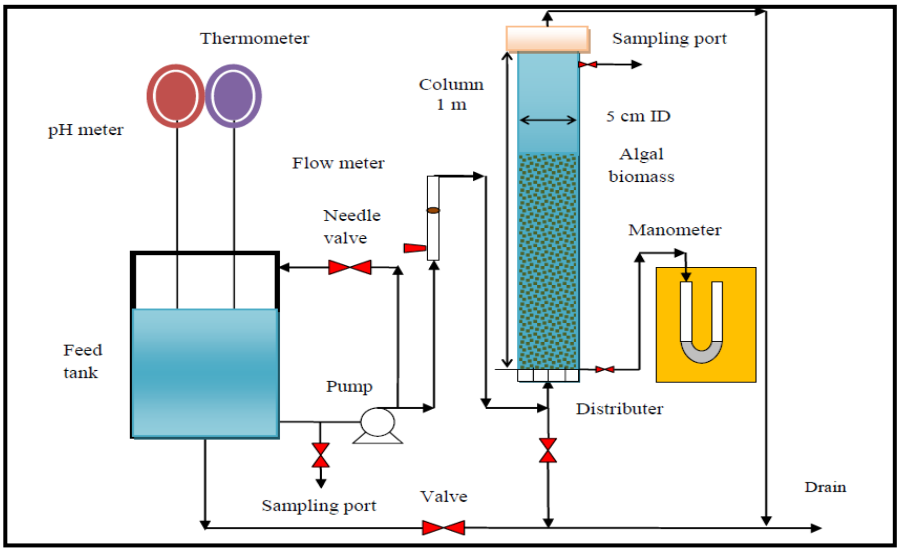

Figure 1. Experimental fluidized bed setup, A: Metal solution tank, B: Pump, C: Flow meter, D: Distributer, E: Column reactor.

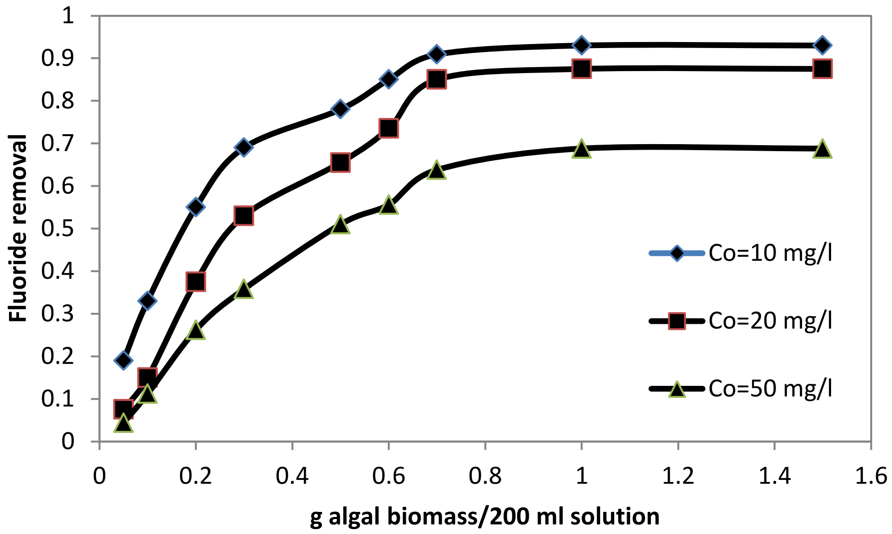

Figure 2. Effect of algal biomass dosage and initial concentration on removal of fluoride from aqueous solution, pH 2.5, at room temperature, contact time: 4 h at 200 rpm.

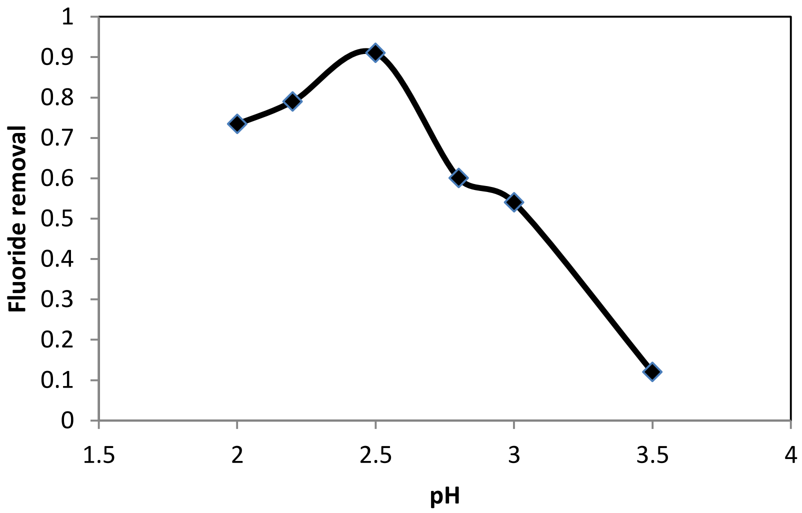

Figure 3. Effect of pH on removal of fluoride from aqueous solution at room temperature, 200 g algal biomass/200 ml, contact time: 4 h at 200 rpm.

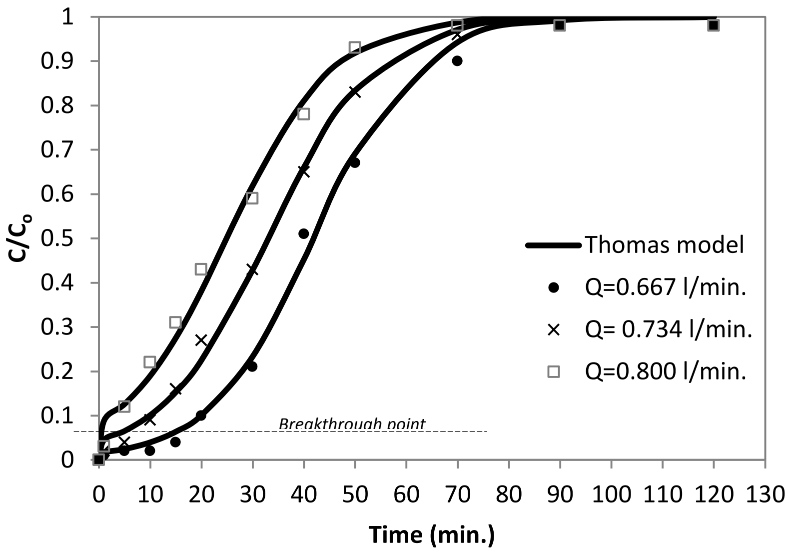

Figure 4. Effect of flow rate on fluoride removal in fluidized bed reactor at pH=2.5, Co=10mg/l, biomass weight =100g using Thomas Model.

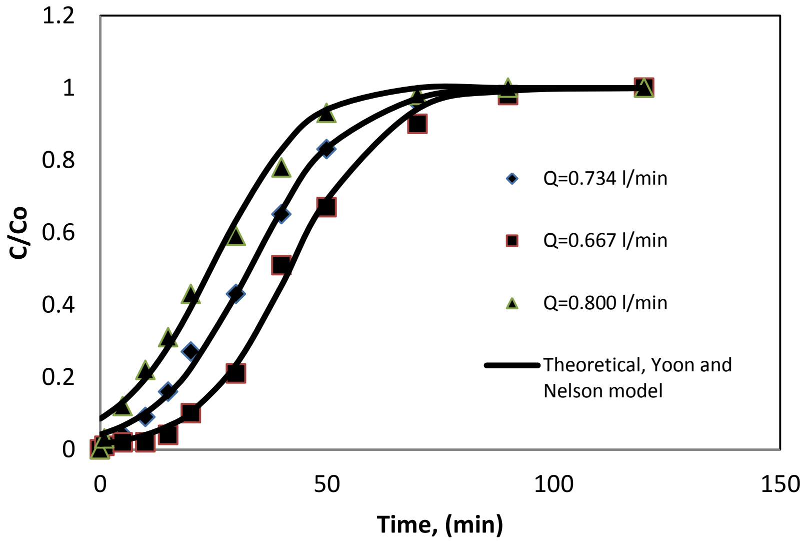

Figure 5. Effect of flow rate on fluoride removal in fluidized bed reactor at pH=2.5, Co=10mg/l, biomass weight =100g using Yoon and Nelson Model.

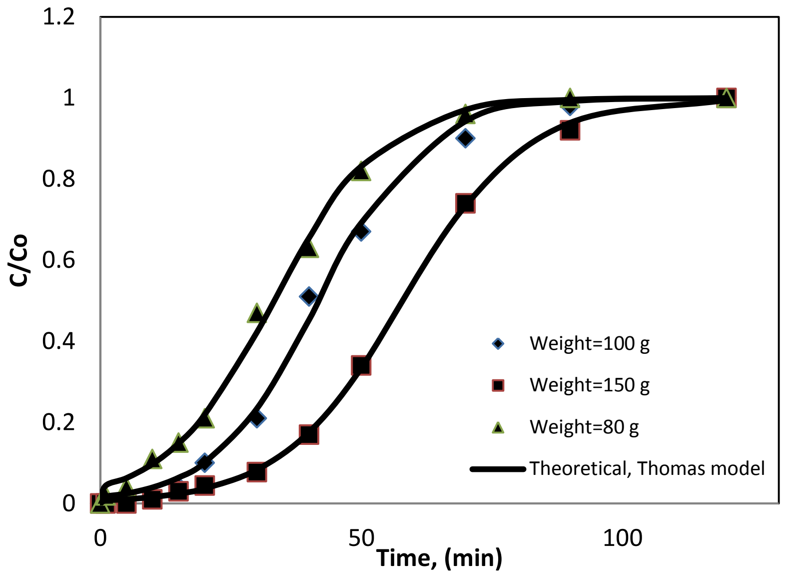

Figure 6. Effect of algal biomass weight on fluoride removal in fluidized bed reactor at pH=2.5, Co=10mg/l, flow rate =0.667 l/min using Thomas Model.

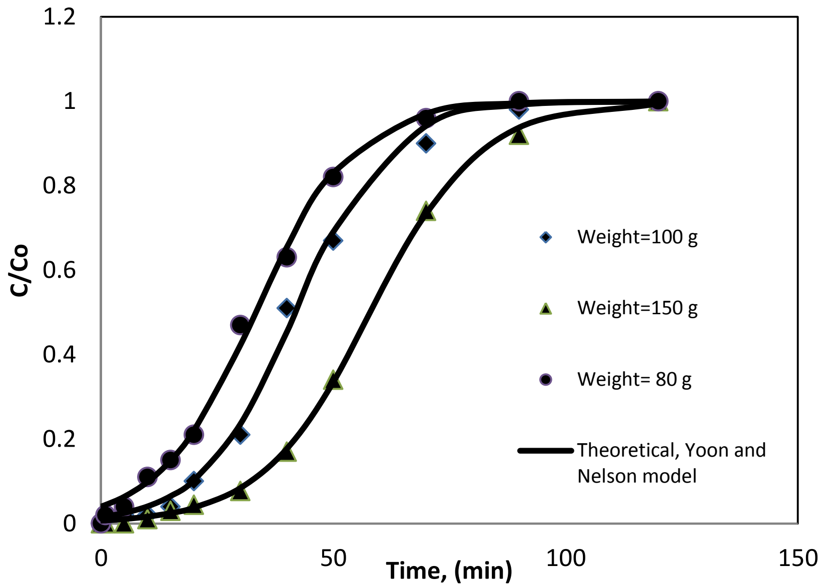

Figure 7. Effect of algal biomass weight on fluoride removal in fluidized bed reactor at pH=2.5, Co=10mg/l, flow rate =0.667 l/min using Yoon and Nelson Model.

Fabrication Of TiO_2 , V_2O_5 Thin Film (Super Hydrophobic Surface)By Powder Coating Technique

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ABSTRACT

In this research, deposition of titanium oxide (TiO_2) and vanadium oxide (V_2O_5) thin film in different mixing percentage (0, 25 ,50, 75 and100)% on the substrate of glass .The coating thickness was (50 nm).

In this research contact angle was measured and the effect of weather conditions. Results showed that the value of the contact angle of the prepared films reached its highest value at 50% (TiO_2+V_2O_5) was 160º.

The results showed that the optical transmittance of TiO_2 and V_2O_5 thin film decrease with increasing the deposition angle and decrease with increasing V_2O_5 proportion.

KEY WORDS :TiO_2,V_2O_5,thin film ,contact angle, optical transmittance, super hydrophobic surface.

تصنيع أغشية رقيقة من TiO_2 , V_2O_5 (سطح فائق الرفض للماء) بتقنية طلاء المسحوق

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الخلاصة:

في هذا البحث، تم ترسيب أوكسيد التيتانيوم (**TiO_2**) وأكسيد الفناديوم (**V_2O_5**) بشكل غشاء رقيق عند نسبة خلط مختلفة (**0** و**25** و **50** و **75** و **100**)% منها على قاعدة من الزجاج. وبسمك طلاء (**50** نانومتر)**.**

في هذا البحث تم قياس زاوية الاتصال وتأثير الظروف الجوية **.** وأظهرت النتائج أن قيمة زاوية الاتصال من الأفلام المعدة بلغت أعلى قيمة لها عند نسبة خلط **50**٪(**TiO_2**، **V_2O_5**) و كانت (**160**°) .

وقد تم فحص النفاذية البصرية؛ وأظهرت النتائج أن النفاذية الغشاء الرقيق لكل من **TiO_2** و **V_2O_5**انخفضت مع زيادة زاوية الترسب ومع زيادة نسبة **V_2O_5** في الخليط.

الكلمات الرئيسة:TiO_2 ، V_2O_5، غشاء رقيق، زاوية الاتصال، النفاذية البصرية، سطح فائق الرفض للماء.

1. INTRODUCTION

Recently titanium oxide (TiO_2) vanadium oxide V_2O_5 ultra thin films have been investigated with regards to their remarkable optical, electrical and photo electrochemical properties.

A number of methods have been employed to fabricate thin films, including e-beam evaporation ,M.Z. OBIDA, 2005, sputtering, M. N. ESFAHANI 2008, chemical vapor deposition S.H. LEE

et.al ,2001and sol-gel process , J. YU, X. ZHAO, 2001, and Q. ZHAO. Among these methods the sol-gel process is one of the most appropriate techniques to prepare thin film.
Application of (TiO_2 ,V_2O_5) like microfiltration media properties, catalytic reactors, cathodic protection, orthopedics. Contemporary orthopedics commonly uses various types of implants which replace damaged or malfunctioning parts of the osteoarticular system. The implants are manufactured using a number of construction materials fulfilling specific requirements. To numerous metallic materials belong stainless steel and titanium alloys, W.A. Seattle, 2006.
The materials used for the implants working for a long time in a living organism environment ought to be bio-acceptable, resistant to the influence of the tissue environment, and compatible biochemically. Also the implant surfaces are known to be very important, because their chemical, biomechanical, and topographic features influence the behavior of cells during the initial stage of the implant integration with the surrounding tissues, ultimately determining the speed and the quality of new tissue formation M.Z. OBIDA, M. N. ESFAHANI.
Physical properties of metallic materials which accelerate the development of bone–implant interactions can be improved by various techniques of surface film engineering, e.g. by the deposition of ultra thin oxide films by the sol–gel method, S.H. LEE et.al.

The main purpose of the present paper is fabrication of (TiO_2 ,V_2O_5) ultra thin films deposited on the surfaces of glass from its powders.

2. EXPERIMENTAL WORK:

This work includes many steps;
A- THE MATERIALS USED FOR THE PREPARATION OF THIN FILMS:-
The materials were used in this work to fabricate thin film are TiO_2 and V_2O_5 powders. These powders are prepared in sequent process is mentioned below:
Sieving process, milling process, and sieving process, particle size measurement process, preparation of materials ratio.

Sieving process was carried out in Material Engineering Department /University of Technology by the equipment device. Where using sieves measurements (93, 75.53, 38, 25) µm.
Milling process were done in Material Engineering Department /University of Technology by the equipment device, this process in 3 hour for each powder. Ball mill model 9 variable speed.
Particle size test was carried out in Advanced Materials Research Center at the Technology and Science Ministry. Specification of the device are (SALD-2101) laser diffraction particle size analyzer shimadzu. The results of the powder that was used in the research are as follows: V_2O_5=0.421 µm , TiO_2 = 0.390µm as in **fig (1)** and **(2)**.

Particle of powder materials have been weighed according to the selected ratio to prepare batches for the spray process by using balance device type Denver max weight is (210) g. This method are described in table (1).

B-SYSTEM PREPARATION:-
The system which is used for preparation of thin films by powder deposition process indicated in **fig (3)**.
This systems consists from a-nozzle b- compressor device c- electric heater d-flow meter e-beaker g –connection f- temperature measuring device remotely.

C- SUBSTRATE PREPARATION:-

All glass sheets were investigated in this work as substrate for preparation of surface in standard dimension as (5x2x0.2) cm and purity (99.99%). Cleaning process for the glass substrates was done by ethanol alcohol for 10 min , M. Mahdi1, 2009, rinse with distilled water, drying in air. After this operation the samples were putted and fixed on the electric heater with control temperature.

D- SPRAYING PROCESS:-

Pre chamber of the nozzle is designed as a unit for mixing carrier gas and for gas-powder, which moves down from the powder feeder to pre chamber. Low velocity gas-powder mixture entrances into pre chamber. Low-velocity gas- powder mixture moves from the feeder into pre chamber under high pressure (value of static pressure in powder mixture must be higher than pressure of carrier gas). That is why powder feeder must be designed considering high level of pressure inside. Pre chamber is connected to nozzle. Gas which we used in this work is air. Flow gas determine is (2.5 l/min) , at pressure (7) bar ,temperature is (25) C°. In the spray, unit powder is accelerated and heated by gas flow. After leaving the nozzle, particles interact with substrate and create a coating.

e- ANNEALING : was done at (350)C° for (one hour) in furnace type German origin (Nabertherm), maximum temperature up to 1100C° .

f- TESTING **:**

1- CONTACT ANGLE TEST:- Sample has been used to measure the contact angle for the droplet. According to the specification ASTM No (813-1990), ASTM,1988.

In this test, it is used the following items:-

a - rule b - camera type and strength enlarge(16 M pixel) to take pictures of the drop for each sample c - camera holder d - protractor e - light source f - needle or tube lattice equipped with a drop of water g - stopwatch h - thermometer and humidity k – computer. After that, contact angle can be plotted for each drop. Measure the angle from the right equal measure from the left. Samples that were used are st.st. Which has been stored in closed containers in order to keep this coat and uses gloves or carry special forceps.

Contact angle e apparent are shown in **fig(4)**, droplet is shown in **fig(5)**.

2- UV SPECTROMETER

TiO_2 and V_2O_5 thin films on glass substrate were irradiated by UV-VIS spectrophotometer.The device to measure the optical transmission of film is shown in figure (6). we were recorded the optical absorption and transmission for glass samples by UV-VIS spectrophotometer. From these it can find properties of the coating, thickness accurately by the equations (1) and (2) , M. Al-Mudhaffer, 2010.

$$\mathbf{r = (n-1)^2/(n+1)^2} \qquad \mathbf{(1)}$$

n : refractive index(dimensionless)

$$\mathbf{t = (1-r^2) * e^{-\alpha t}} \qquad \mathbf{(2)}$$

t: optical transmittance (percentage)

α: absorption coefficient(cm^{-1})

t: coat thickness (µm)

This device is available in nanotechnology and advanced materials research center / the university of technology with range (200-1200) nm.

3. RESULTS AND DISCUSSION

Fig(7) shows the contact angles of all the film which have been prepared at different deposition angles before exposure to Iraqi weather. In this figure note that component on the horizontal axis powder mixture concentration ratios (wt%) and the values of the contact angles in degrees on the vertical axis.

a-EFFECT OF COMPOSITION:-

The change ratios of powders included in the mixture, which was deposited affect on the value of the contact angle on the one hand. This figure represents a pre-exposure to weather conditions. The value of the contact angle of the titanium oxide reached almost 120º, and almost rise to 160º , X.Ding and Z. Wang, 2011.

b-Effect of deposition angle:

In the same figure an increasing the angle of deposition lead to increase the contact angle at all mixture concentration. At change of the deposition angle and this corresponds with the previous research, reaching to 151.5º, C. Xue and E.Denver, 2008.

Either in the case of vanadium oxide, it find that the value rise and reached 160º also with increasing deposition angle. and can conclude that angle deposition played a key role in changing the coat condition from hydrophobic to super hydrophobic and this value is identical with the reference ,K. Senthila and M. Kanehira, Z. Zhang, 2011.

Fig(8) illustrates change in contact angle after exposure to Iraqi weather condition during four months full of all samples. In this figure it noticed that the value of the change was few, as happened simple change in contact angle value and nearly all samples after four months full due to the influence of moisture and this corresponds to the reference , C.V. Ramana et.al, 2004.

In **Fig (9)** contact angle was taken per month for four months and four samples that showed the highest value contact angle through the first examination in **Fig(8)** with concentration (50% TiO_2,50%V_2O_5) and then examined for each month separately. Results also showed simple decrease in the values of the contact angle because increased humidity, which corresponds to (any moisture ratios) months installed in the same **Fig (9)**, because the increased humidity caused an increase in the area of exposure which cause that decreased M.Z. OBIDA et.al., 2005, C. Xue and E.Denver, 2008.

Optical transmittance have many application varied. Because it's important to have the coat or thin film high percentage of transparency in the area over the visible spectrometer. Therefore be appropriate for the application , C.V. Ramana et.al.

Fig (10:a) represents transmittance value of 100% TiO_2 and0% V_2O_5 and note that with increasing angle low transmittance because decrease case irregular film, which we observed in the images imaging microscopy in the preceding paragraph. The same think is true for the other thin films figures (10: b ,c ,d , e) that represent mixtures. Including all note on the whole low transmittance with increasing angle deposition, W. Gulbinski et.al, 2003.

4. CONCLUSIONS:

a-Real contact angle that have been measured (155º). That means the film was super hydrophobic especially at deposition angle of 45º.

b- It is clear that the optical transmittance of TiO_2 and V_2O_5 thin films decrease with increasing the deposition angle and decrease with increasing V_2O_5 proportion .Where it was in the case of pure titanium dioxide (82%) and decrease to (40%), maximum transmittance is (95%).

c-The contact angle measurements have highest value for mixture (50% TiO_2, 50%V_2O_5) increased with high angular deposition hitting (160^o) at deposition angle (45^o).
d- The influence of weather conditions was limited at this deposition angle (45^o) for mixture (50% TiO_2, 50%V_2O_5) after exposure to four months consecutive full of Iraqi weather conditions.

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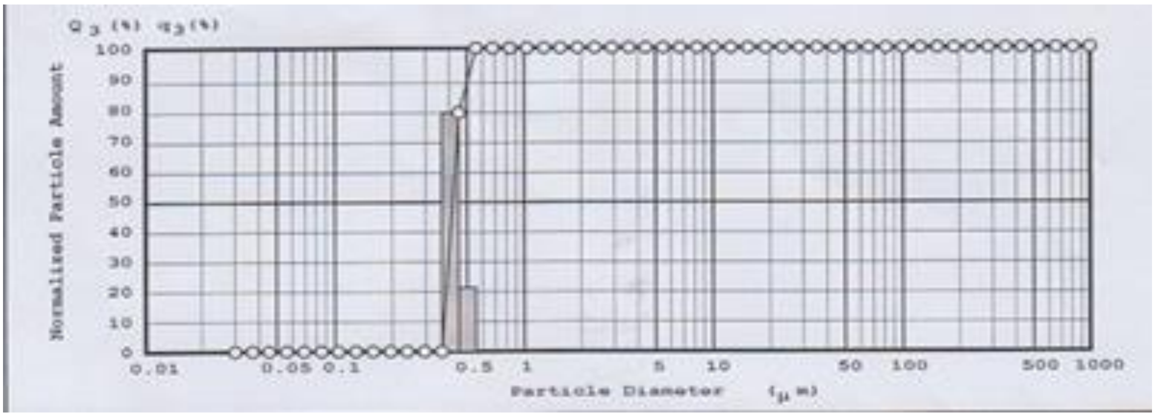


Figure (1) Particle size for V_2O_5.

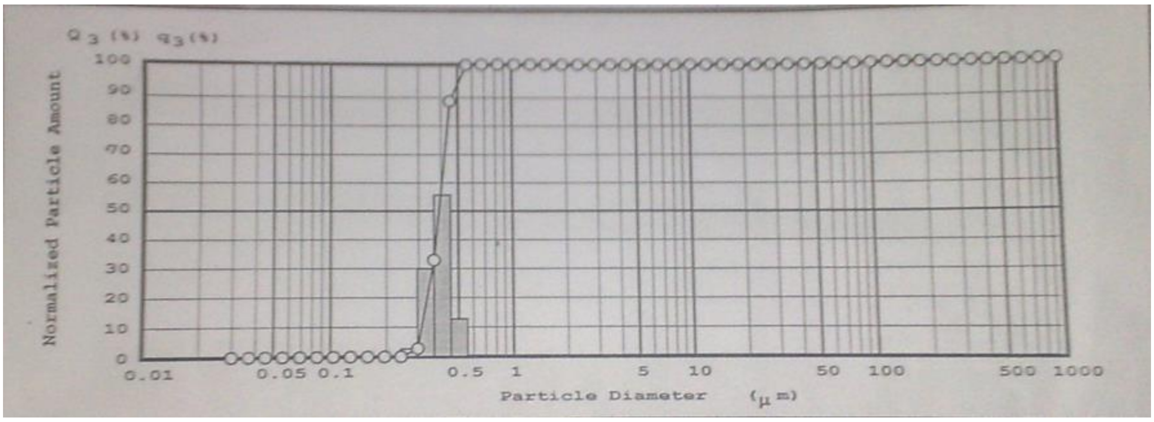


Figure (2) Particle size for TiO_2.

Table 1. Ratio of mixing powder materials according to weight percentage.

Sample symbol	A	B	C	D	E
Composition	100%TiO_2+ 0%V_2O_5	75%TiO_2+ 25%V_2O_5	50%TiO_2+ 50%V_2O_5	25%TiO_2+ 75%V_2O_5	0%TiO_+ 100%V_2O_5

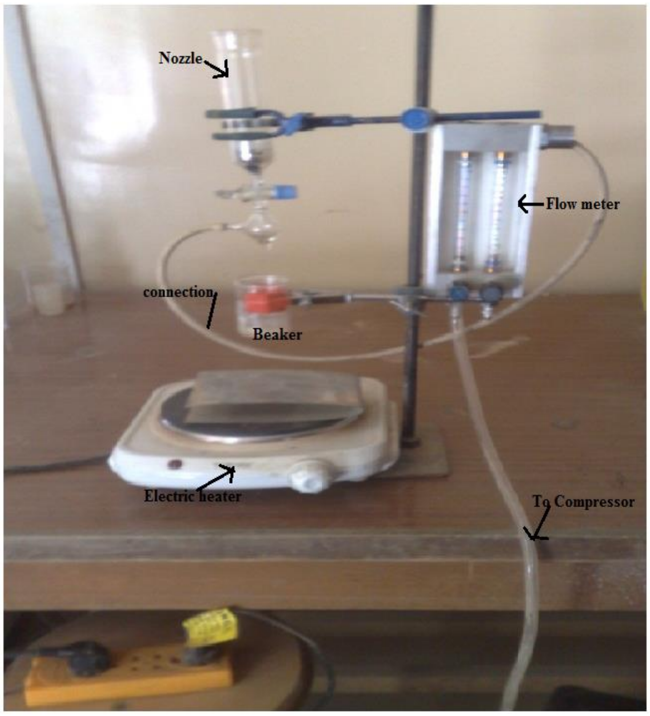


Figure 3. System for process

Figure 4. Contact angle apparatus

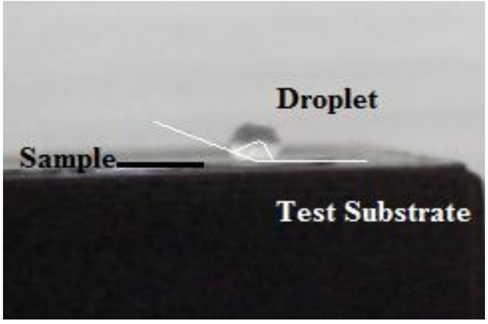


Figure 5. Droplet on the sample

Figure 6. UV-VIS spectrometer device

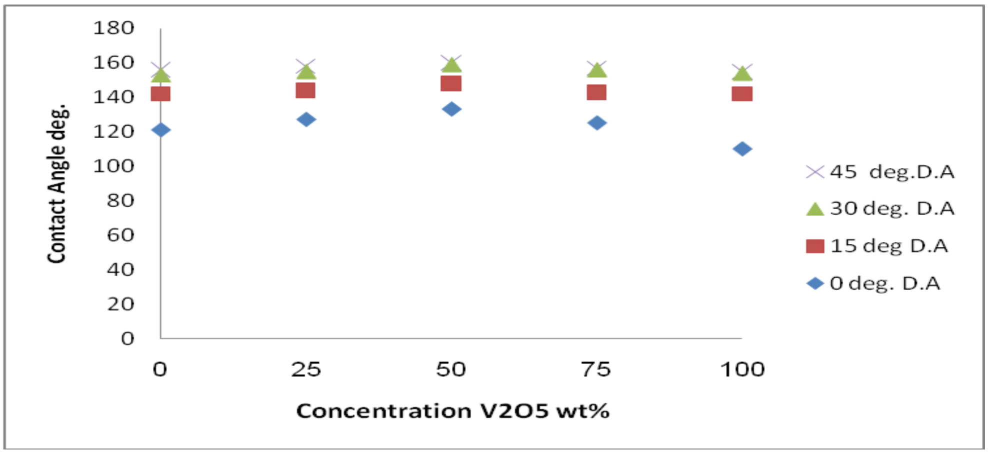


Figure. 7. Effect of V_2O_5 wt% on contact angle results before exposure to weathering and deposition angle.

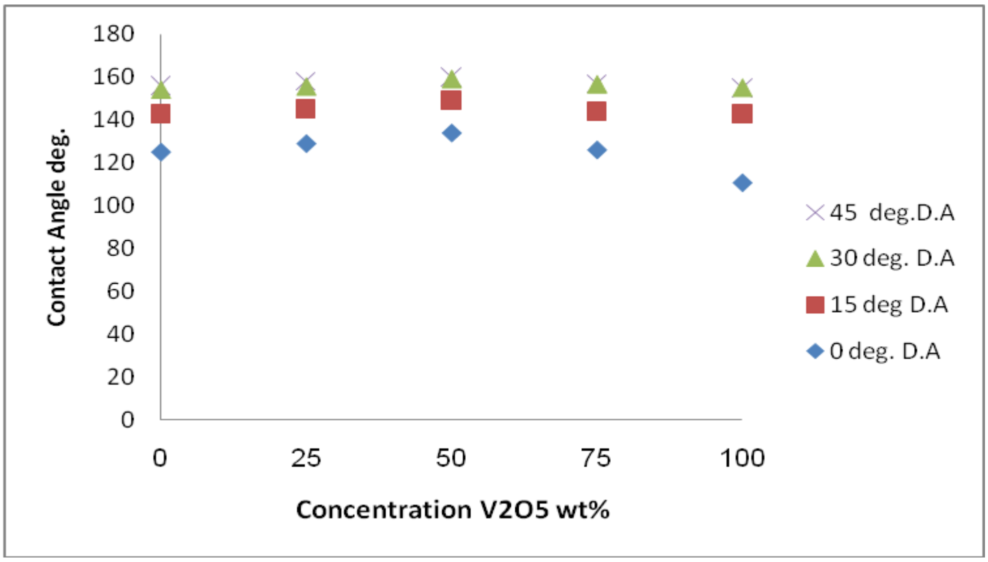


Figure 8. Effect of V_2O_5 wt% on contact angle results before exposure to weathering and deposition angle.

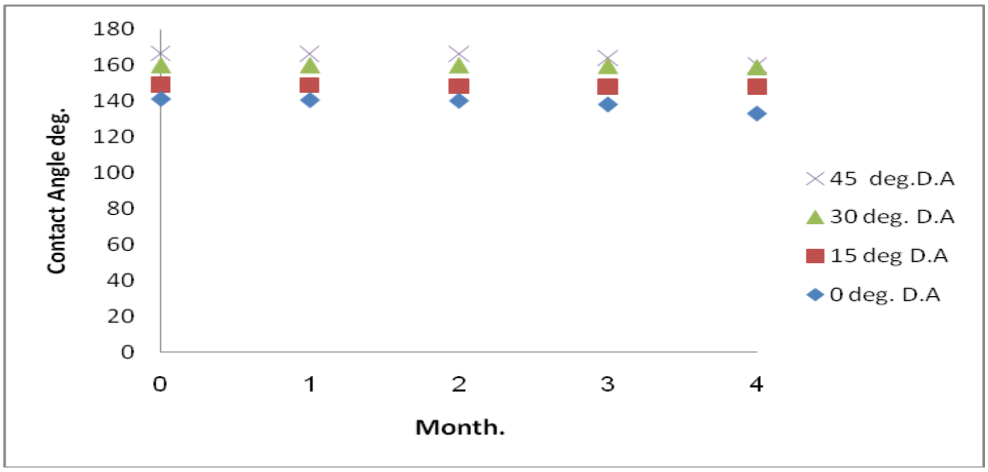
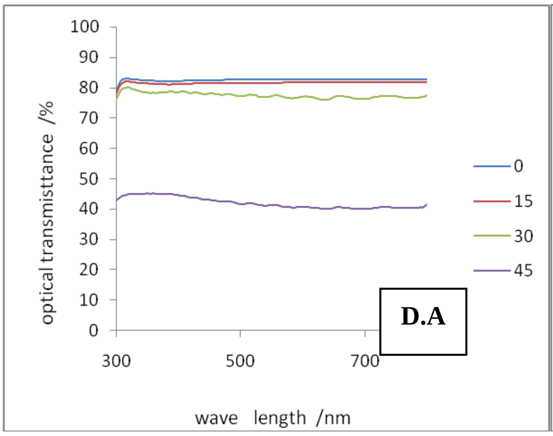
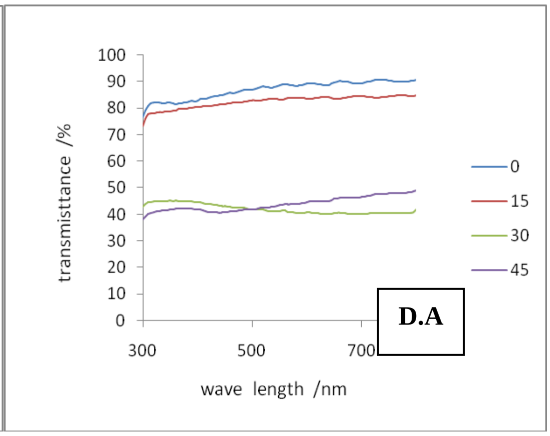


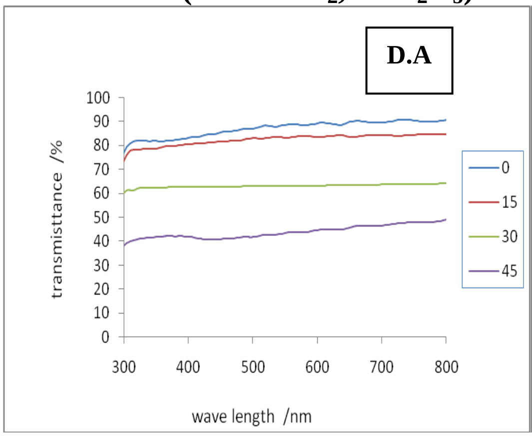
Figure 9. Effect of weathering condition on contact angle for (50% TiO_2,50%V_2O_5) results after exposure to 4 months weather condition, and deposition angle.



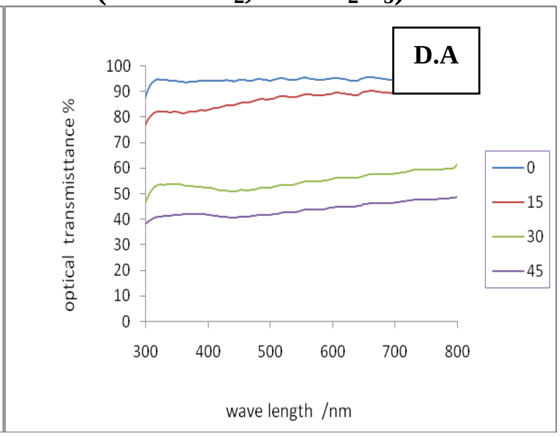
a:(100% TiO_2,0% V_2O_5)



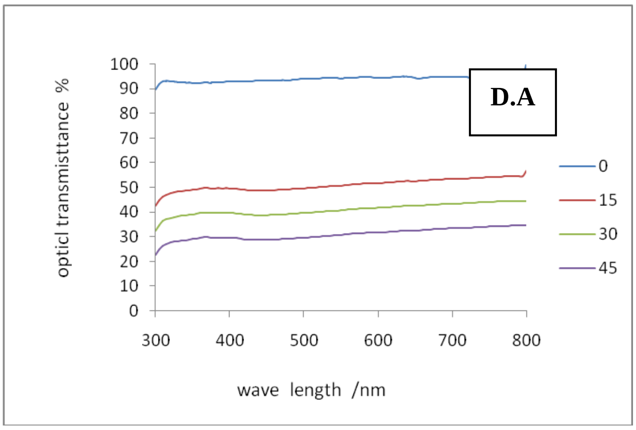
b:(75% TiO_2,25 % V_2O_5)



c:(50% TiO_2, 50% V_2O_5)



d: (25% TiO_2, 75% V_2O_5).



e: (0 % TiO_2, 100 % V_2O_5)

Figure 10. Effect of wave length and deposition angle on optical transmittance of thin film at different concentration.

Torsional Resistance of Reinforced Concrete Girders with Web Openings

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ABSTRACT

In this study, a three dimensional finite element analysis was utilized to study the behavior of reinforced concrete T-girders with and without web openings under pure torsion by using ANSYS APDL 15.0 program. Fourteen reinforce concrete T- girders were analyzed; one of the girders (without web openings) was modeled as a control girder. The analysis variables considered for the other girders are: size, shape, position of web openings, number of web openings and the method was used to strengthen the member at openings, (using internal deformed steel bars as in the case where the openings are planned before casting the girders). To study the general behavior of finite element models, torque-angle of twist plots at the end of the span near the loaded arms were represented. From this relation, it was showed a decreasing in the strength of the T-girders with web openings under the torsional loads and increasing of the angle of twist. The results were analyzed in terms of torque twist characteristics; ultimate torque, crack patterns, crack width, warping and stresses. These terms were presented and a comparison between the finite element results was made.

Keywords: finite element analysis, torsion, reinforced concrete, web opening, girder.

مقاومة اللي للأعتاب الخرسانية المسلحة حاوية على فتحات وترة

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الخلاصة

تم من خلال هذا البحث دراسة سلوك العتبات الخرسانية المسلحة لعتبات بشكل T الحاوية على فتحات وعتبات بدون فتحات تحت تأثير عزم اللي الصرف ;تمت نمذجة العتبات بأستخدام طريقة العناصر المحددة لنماذج ذات ابعاد ثلاثية بأستخدام برنامج ANSYS APDL 15.0، حيث تم تحليل اربعة عشر نموذج احدها بدون فتحه والذي يعتبر النموذج المصدري حيث تم مقارنة نتائج بقية النماذج معه. المتغيرات التي تم استخدامها عند دراسة المقارنة مع االنماذج الأخرى هي: حجم وشكل وموقع وعدد الفتحات المستخدمة وطريقة تقوية الفتحات التي تتم بأستخدام تسليح داخلي حول الفتحات عند التصميم. ولأجل دراسة العلاقات المتعلقة بالنماذج والمصممة بطريقة العناصر المحددة, كالعلاقة بين عزم اللي الصرف وزاوية الألتواء والتي تم قياسها عند نهاية مقطع العتبة القريبة من الذراع الذي يسلط عليه الأحمال, وبشكل عام ومن خلال هذة الدراسة وجد تناقص في مقاومة العتبات لعزوم اللي الصرف وزيادة في مقدار زاوية عزم الألتواء عند وجود الفتحات .و تمت ايضا دراسة نتائج حساب اقصى عزم التواء وشكل وسمك التشققات ودراسة الأنحناءات والأجهادات وتم اجراء مقارنة فيما بينها.

كلمات المفتاح:العناصر المحددة, عزم الألتواء, الخرسانة المسلحة, الفتحات, العتبات.

1. INTRODUCTION

In current buildings construction, a transverse opening in reinforced concrete (RC) beam is often presented for the passage of utility pipes and ducts. These pipes or ducts are requisite to accommodate with fundamental services such as air-conditionings, electricity, water supplies, computer networks, and telephone wires, **Ahmed, et al., 2012**. The passing of these ducts through the openings in the RC floor beams eliminates a significant amount of dead space and results in a more economical and compact design, **AL-Shaarbaf, et al., 2007**.

The effects of an opening on the RC beam behavior and strength must be considered; including transverse openings in the web of a RC beam induces high stress concentration at opening corners, alters the simple beam behavior to a more complex one and reduces beam stiffness. While providing a large opening, the effects on service and ultimate load behaviors of the beam must be properly accounted for in the design, **AL-Shaarbaf, et al., 2007**. An opening in a RC beam creates discontinuity in the stresses normal flow, this leads to early cracking of concrete due to stress concentration at edges of the opening. To avoid this, special reinforcement enclosing the opening should be provided in the form of internal or external reinforcement. Internal reinforcements are steel bars provided along with the main reinforcements during casting. External reinforcements are applied externally around opening in the form of jacketing of composite materials like glass fiber or carbon fiber reinforced polymer called GFRP or CFRP, **Venugopal, 2014.**

2. BACKGROUND

Daniel and McMullen, 1977, presented in their paper a method for predicting the torsional strength of a concrete beam that contains an opening and is reinforced both longitudinal and transversely. Sixteen beams were tested of which two did not have an opening (solid beams). The other beams contained an opening that was placed symmetrically except in B47 and B48 with unsymmetrically position of opening. All specimens were subjected to pure torque at their solid ends. The load was applied in increments and after the application of each increment of load, the strains, rotations, and deflections were recorded and the cracks were marked.

McMullen and Daniel, 1975, displayed equations for predicting the torsional strength of RC beams that contain openings to be used as service ducts. The results were compared with the test results of 29 concrete beams. The strength of beams containing a small opening can be larger than the strength predicted by the theory because the spiral crack extends into the solid portion of the reinforced concrete beam. Although, all the tested beams were subjected to pure torsion, the analysis includes the moment and the shear due to self weight of the RC beam and thus can easily be outspread to include members supporting external loads that cause bending and shear.

Venugopal, 2014, tested eleven beams of the same dimensions. Beams were divided into two series. The first series was cast with circular opening whereas the second was cast with rectangular openings of the same cross sectional area. One beam without web openings was also casted and treated as control beam. Each series consisted of five beams; the first beam had a centrally located single opening and the remaining four were cast with two symmetrically located openings. The other three beams with two openings of both series were retrofitted with bi-directional GFRP fabric.

Fawzy et al, 2014, studied the use of externally bonded fiber reinforced polymers to strengthen concrete beams with a large web opening subjected to pure torsion. An experimental work was carried out to investigate the torsional behavior up to failure of nine RC beams having the same dimensions and reinforcement. One of them is solid without opening as a reference beam and one of the remaining eight beams was tested without any strengthening and seven beams were strengthened with carbon fiber reinforced polymer (CFRP) with different schemes. The major parameter included in this study was the strengthening effect of different schemes of CFRP sheets on behavior of RC beams with a large web opening under pure torsion.

3. OBJECTIVE

The research investigation aimed to study the behavior and strength of a reinforced concrete T-girder with and without a web opening under pure torsion, using ANSYS APDL 15.0 Program. The major variables of the study were the number, size, shape, position of web openings along the span and the reinforcement around openings. During the static analysis, the variables measured for each T-girder were torque versus angle of twist values at the free end of the girder near the loading arm on both concrete and steel, crack pattern, crack width, warping and stresses.

4. VERIFICATION OF THE FINITE ELEMENT IDEALIZATION

The validity and accuracy of finite element idealization were studied and checked by analyzing reinforced concrete beam (B1) that tested experimentally by **Mansur et al. 1983a** as shown in **Fig.1b**. The aim of the comparison is to ensure that the elements, material properties and convergence criteria are adequate to model the response of the beams and to be sure that the simulation process is correct. The concrete beam was modeled using 8-node brick elements (Solid 65). The reinforcing bars were modeled using 2-node element (Link 180). The loading arm and the steel plates were modeled using (Solid 45) elements, as shown in **Fig.1a**. Due to the nature of the torsional problem, where there are out-of-plane as well as in-plane forces, the model is generated with mainly three dimensional elements. A square or rectangular mesh is recommended and the total number of nodes equals 3223 while the total number of elements equals 3615. The shear transfer coefficients for closed and open cracks of values 0.6 and 0.7, respectively after several of trails. Convergence criteria was set as (U = 0.05) and the Norm was infinite.

4.1. RESULTS OF FINITE ELEMENT VERIFICATION MODEL

Fig.2 represents the relationship between the torque and the angle of twist, and revealed that the general behavior for the tested beams in torsion is well established by the adopted numerical model. The analytical results show that the prediction of the ultimate torque capacity of the beam was close to the experimental result; while the prediction of angle of twist was smaller than the experimental result by 24%.

5. FINITE ELEMENT IDEALIZATION OF THE T-GIRDER

The (Solid65) element was used to model the concrete and (Link180) element was used to model steel reinforcement, while the (Solid45) element is used for modeling the steel plates at the supports and steel arms. Fourteen reinforced concrete T-girders were modeled, details are given in **Table 1**. The (Solid65) element requires linear isotropic and multi-linear isotropic material properties to properly model concrete. The modulus of elasticity of the concrete, (EX = 23500 MPa) and Poisson's ratio is taken as (0.2). The uniaxial cracking stress is based upon the modulus of rupture which was (f_r =3.1). The uniaxial crushing stress in this model was based on the uniaxial unconfined compressive strength ($f_{c'}$= 25 MPa). For the (Link180) element, the bilinear model requires the yield stress (f_y = 400 MPa) for longitudinal and stirrups reinforcement, as well as the hardening modulus of steel to be defined as zero. Elastic modulus is defined as (EX = 200000 MPa) and Poisson's ratio PRXY as (0.3). For the (Solid45) element, the element was modeled as a linear isotropic element with a modulus of elasticity for the steel as (EX =200000 MPa) and Poisson's ratio PRXY as (0.3).

5.1 Dimensions and Details of T-Girder

Dimensions of the tested T- Girders are: length of girder is 20000 mm, width of flange is 1000 mm, thickness of flange is 200 mm, width of web is 400 mm and depth of web is 1200 mm. A concrete cover of 40 mm was used in the web of the T-girder and 25 mm in the flange, see **Fig.3**. Dimensions of the steel arms are (500×200×500) mm from the flange, (500×1200×800) mm from the web and for the steel plates are (500×50×400) mm. Diameter of circular openings is 400 mm and 600 mm which equals about % 33.3 and % 50 of the depth of web; the depth of the rectangular and square web openings was % 33.3 and % 30 of the depth of web. The T-girders were reinforced with 9Ø36 mm deformed bars as flexural reinforcement. The shear reinforcement (stirrups) was Ø12 mm deformed bars at 250 mm c/c. Bars of Ø12 mm deformed bars at 500 mm c/c were used as horizontal and longitudinal reinforcements for the flange of the T-girder. This reinforcement was used for all T-girders that were with unstrengthened openings except girder (G8) and (G13). T-girder (G8) was strengthened with pre-fabricated internal deformed steel bars (additional reinforcements around opening) consisting of 8Ø12 mm diagonal bars around the openings, 4Ø12 mm horizontal bars above and below the openings and concentrated stirrups Ø12 mm above and below the opening at 50 mm c/c. The additional reinforcement for (G13) increased near the opening greater than the additional reinforcement in (G8). **Fig.4** shows model of the specimens. The shear transfer coefficients for open and closed cracks of values 0.3 and 0.5, respectively. Convergence criteria were set as default and the Norm was L2.

5.2 Modeling of the T-Girder

Full T-girders were used in modeling with proper boundary conditions. The concrete, steel plates and steel arms of the T-girders were modeled as volumes. It should be noted that for specimens

(CG, G1 to G13), some modification of dimensions was made due to geometric constraints from the some elements in the models, i.e. meshing of concrete elements and steel rebar locations.

5.3 Meshing of the T-Girder

The use of a square or rectangular mesh is recommended to obtain good results from the Solid65 element, **Jindal, 2012**, and **Wolanski, 2004**, and using a tetrahedron mesh around the web openings as shown in **Fig.5** except T-girder (G3), (G8) and (G13), using a square or rectangular mesh for all. No mesh of the steel reinforcement is needed because individual elements were created in the modeling through the nodes created by the mesh of the concrete volumes as shown in **Fig.7**. The command 'merge items' is used to merge separate entities that have the same location.

5.4 Loading and Boundary Conditions

The analyzed T-girder was supported at a distance of 1.0 m from the ends on cylindrical bearings. These bearings permitted free torsional rotation at the supports as shown in **Fig.6**. A loading arm was attached to the T-girder at each support. The load was applied to one of the loading arms while the other loading arm was held in position in ux, uy, uz directions. The ultimate torsional strength for the control girder was 163.5025 kN.m.

5.5 Parametric Study

In order to investigate the effects of most important parameters affecting the torsional capacity of RC T-girders with web openings, a parametric study have been carried out in this study, these parameters include:

1- Shape of the openings.
2- Size of the openings.
3- Number of the openings.
4- Position of the openings.
5- Strengthen of the openings.

5.6 Results and Discussion

The general relationship between torque and angle of twist is such that, initially linear elastic behavior at a low loading stage was observed, the load gradually increased up to failure. Finite element analysis, using ANSYS program, was used to simulate concrete T-girders with and without single and multiple web openings. The general behaviors of the modeled girders were represented by the torque-angle of twist plots at the end of the span near the loaded arms showed a decreasing in the ultimate torsional strength of the T-girders due to introducing openings in the web, using the same longitudinal and transverse reinforcements except T-girders (G8) and (G13) as shown in **Fig.9** to **Fig.21.**

It has been found for T-girder which casted from ordinary concrete, when the diameter of opening increased, the reduction of ultimate strength increased and the pattern of cracking, as well as mode of failure of the T-girder changed. The depth of the opening with 30%, 33.3% and

50% of the overall depth of the web of the T-girder had an effect on decreasing the ultimate torsional strength of the T-girder and the depth of web opening had a greater effect than the effect of the length of web openings.

Concerning the effect of the shape of the web openings, it was found that there was difference between circular, square and rectangular web openings, the effect of square and rectangular web openings were decreasing the ultimate torsional strength greater than the circular web openings.

The location of the web opening in the center of the web of the T-girder has a larger effect than the position near the end of the T-girder span. The changing of the eccentricity of the web openings showed a decreasing in the ultimate torsional strength of the T-girders for (G7) with % 3.31, while the eccentricity of the web openings showed a decreasing in the ultimate torsional strength of the T-girders for (G9) with % 6.92. This shows that the effect of the eccentricity of the web opening near the flange was less than the effect of the eccentricity of the web opening near the bottom of the web; the flange of T-girder elements loaded with pure torsional had a beneficial effect on their load capacity. The eccentricity of the web opening at the center of the T-girder (G1) has a decreasing of % 3.980 of the ultimate torsional strength.

The number of web openings reduced the torsional strength as it increased. The reduction in ultimate torsional load of (G1) with one circular opening was % 3.980 while for (G5 and G11) with two circular openings was % 5.693 and % 7.868, respectively. For (G12) with four circular openings, the reduction in ultimate torsional load was % 5.000. The different between the results of the above T-Girders was the effect of position of web openings besides the effect of the number of web openings.

The application of strengthening arrangement presented in this research for T-girder (G8) and (G13) with square web opening had an effect on the T-girder deflection, controls cracks around openings, and decreased the ultimate capacities of the girder by about % 7.657 and % 1.440, respectively.

The warping for T-girder without web openings was less than warping of the T-girder with web opening at some position and was greater at other position while the warping near the opening was greater than the warping near the loaded arms. The angle of twist was increased when there was a web opening.

The crack first appeared with spiral view near the opening with an angle of 45° and then extended to the top of the flange and for the entire web of the T-girder with the same angle; the extended cracks greatly increased in the beginning near the bottom of the web than the top of the flange. In general, torsional cracks occurred early at mid span for control T-girder, and at the opening for other T-girders. Increasing the applied loads induced additional diagonal torsional cracks. The crack width increased as the size, number of opening, eccentricity and strength of openings increased.

The maximum stresses appeared around the openings and the lowest stresses appeared at the end of the T-girder. **Fig.8** shows the deformed shape of the control girder CG. **Fig.22** and **Fig.23** show the numerical crack patterns and the numerical XY-shear stress, respectively. **Fig.24** shows the numerical stress intensity of the reinforced concrete for (G13) and **Table 2** shows the summary of numerical torque results.

5.7. Conclusions

Conclusions drawn from the theoretical work are summarized as follows:

1- The general behaviors of the modeled girders were represented by the torque-angle of twist plots at the end of the span near the loaded arms showed a decreasing in the ultimate torsional strength of the T-girders. The depth of web opening had a greater effect than the effect of the length of web openings.

2- Concerning the effect of the shape of the web openings, it was found that there was difference between circular, square and rectangular web openings, the effect of square and rectangular web openings were decreasing the ultimate torsional strength greater than the circular web openings.

3- The location of the web opening in the center of the web of the T-girder has a larger effect than the position near the end of the T-girder span. The changing of the eccentricity of the web openings showed a degreasing in the ultimate torsional strength of the T-girders. The effect of the eccentricity of the web opening near the flange was less than the effect of the eccentricity of the web opening near the bottom of the web.

4- The number of web openings reduced the torsional strength as it increased.

5- The application of strengthening arrangement around web opening had an effect on deflection, controls cracks around openings and on decreasing the ultimate torsional capacity of the T-girder.

6- The warping for T- girder without web openings was less than warping of the T-girder with web opening at some position and was greater at other position while the warping near the opening was greater than the warping near the loaded arms.

7- The angle of twist was increased when there was a web opening.

8- The crack first appeared with spiral view near the opening with an angle of 45° and then extended to the top of the flange and for the entire web of the girder with the same angle; the extended cracks greatly increased in the beginning near the bottom of the web than the top of the flange. In general, torsional cracks occurred early at mid span for control T-girder, and at the opening for other T-girders. The crack width increased as the size, number of opening, eccentricity and strength of openings increased.

9- The maximum stresses appeared around the openings and the lowest stresses appeared at the end of the T-girder.

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Symbols and Abbreviations

E	modulus of elasticity of the material.
f	stress at any strain ε.
f_c'	cylinder compressive strength of concrete, MPa.
f_r	modulus of rupture.
f_y	yield stress of tensile reinforcement.
ANSYS	analysis Systems (Software).
APDL	ANSYS parametric design language.
CFRP	carbon fiber reinforced polymer composites.
FEM	finite element method.
GFRP	glass fiber reinforced polymer composites.
RC	reinforced concrete.
υ	poisson's ratio.
ϴ	angle of twist from torsion.

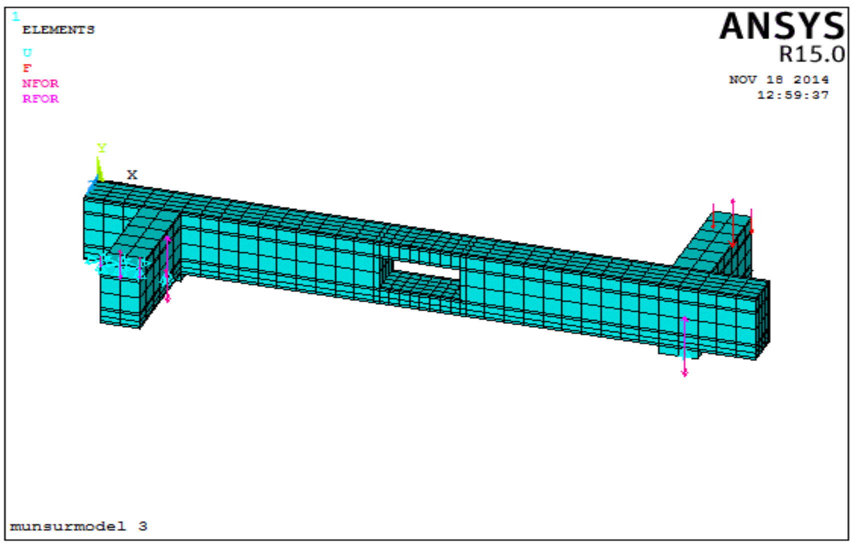


Figure 1a.FE idealization of the beam B1.

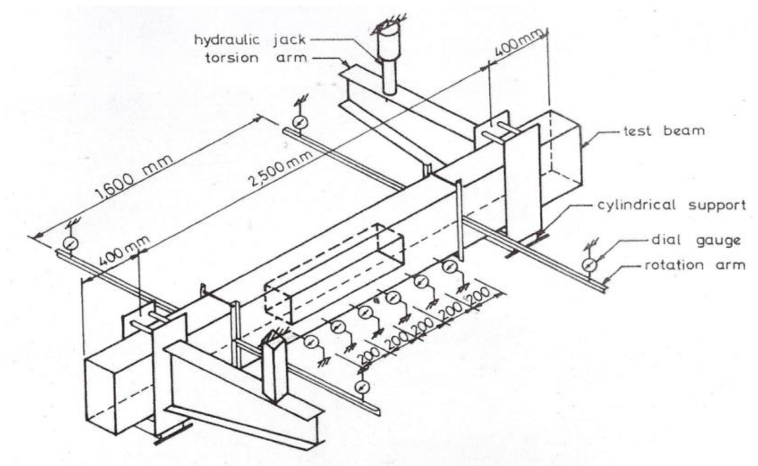


Figure 1b. Test set up and instrumentation of B1.

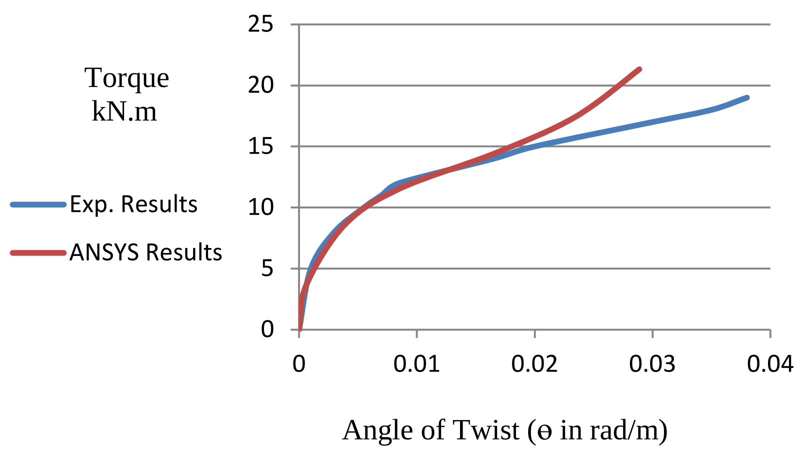


Figure 2. Numerical torque-twist behavior for beam B1.

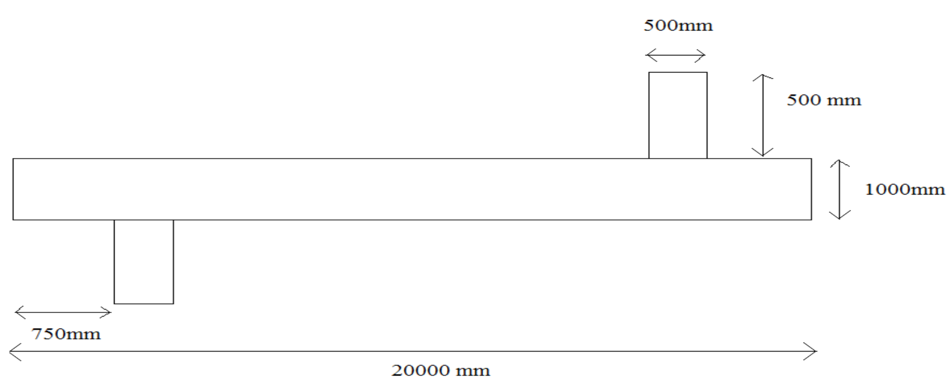
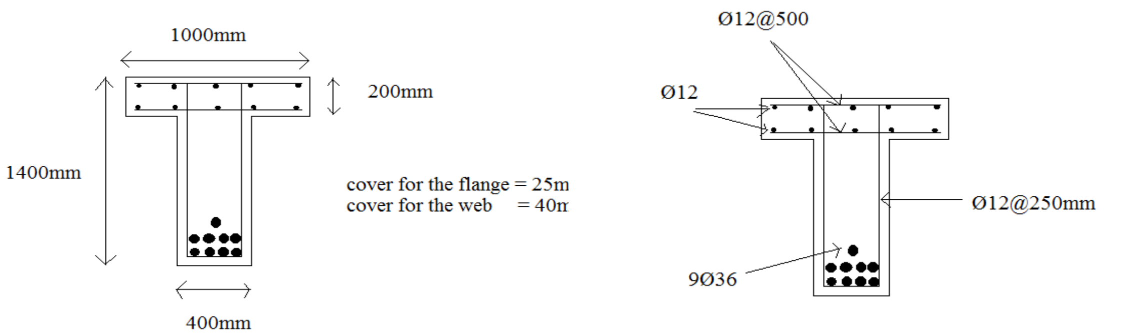


Figure 3a. Top view of the control girder model.



b.Steel reinforcement layout of the control T-girder.

Figure 3. Dimensions and steel reinforcement layout of the control T-girder.

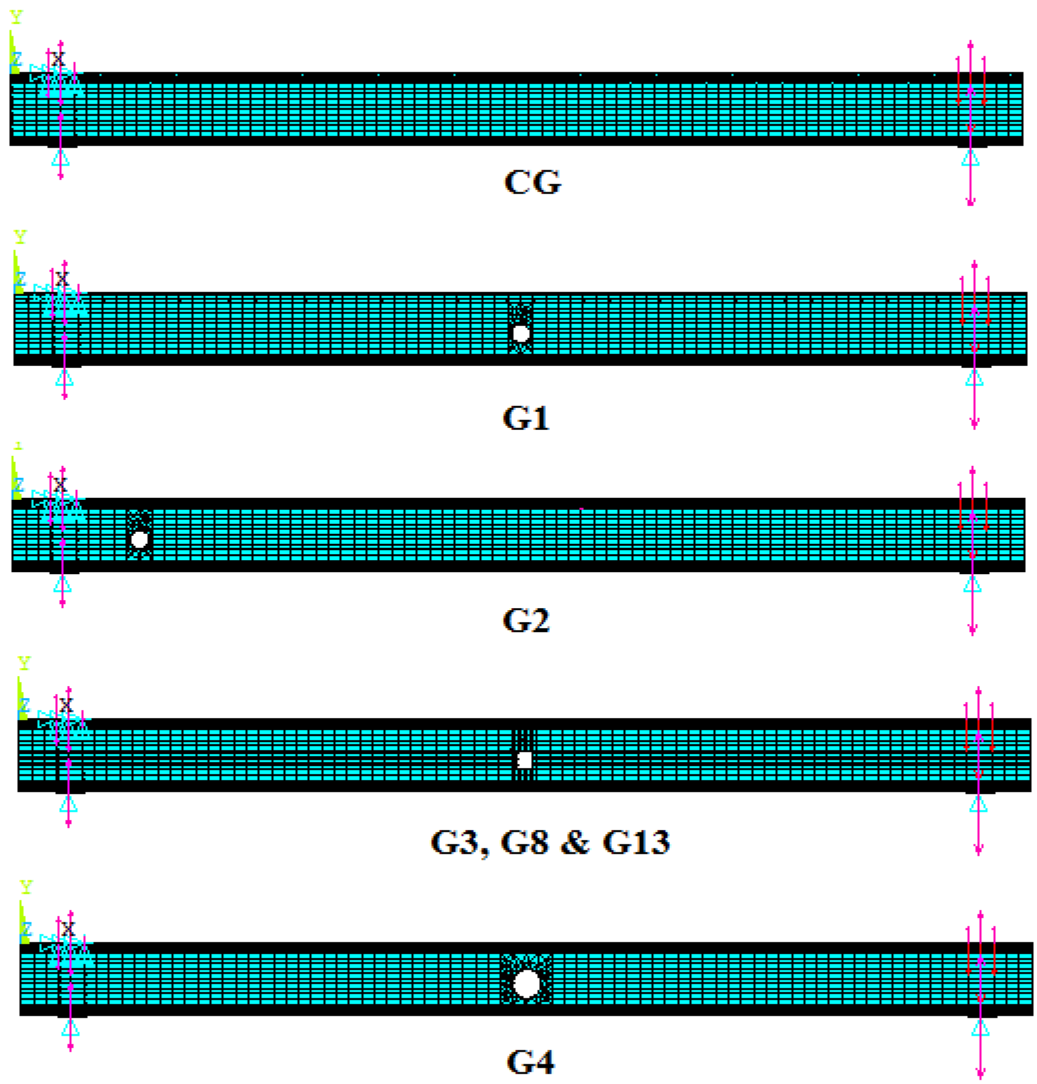


Figure 4a. Model program, from CG to G4, G8 and G13.

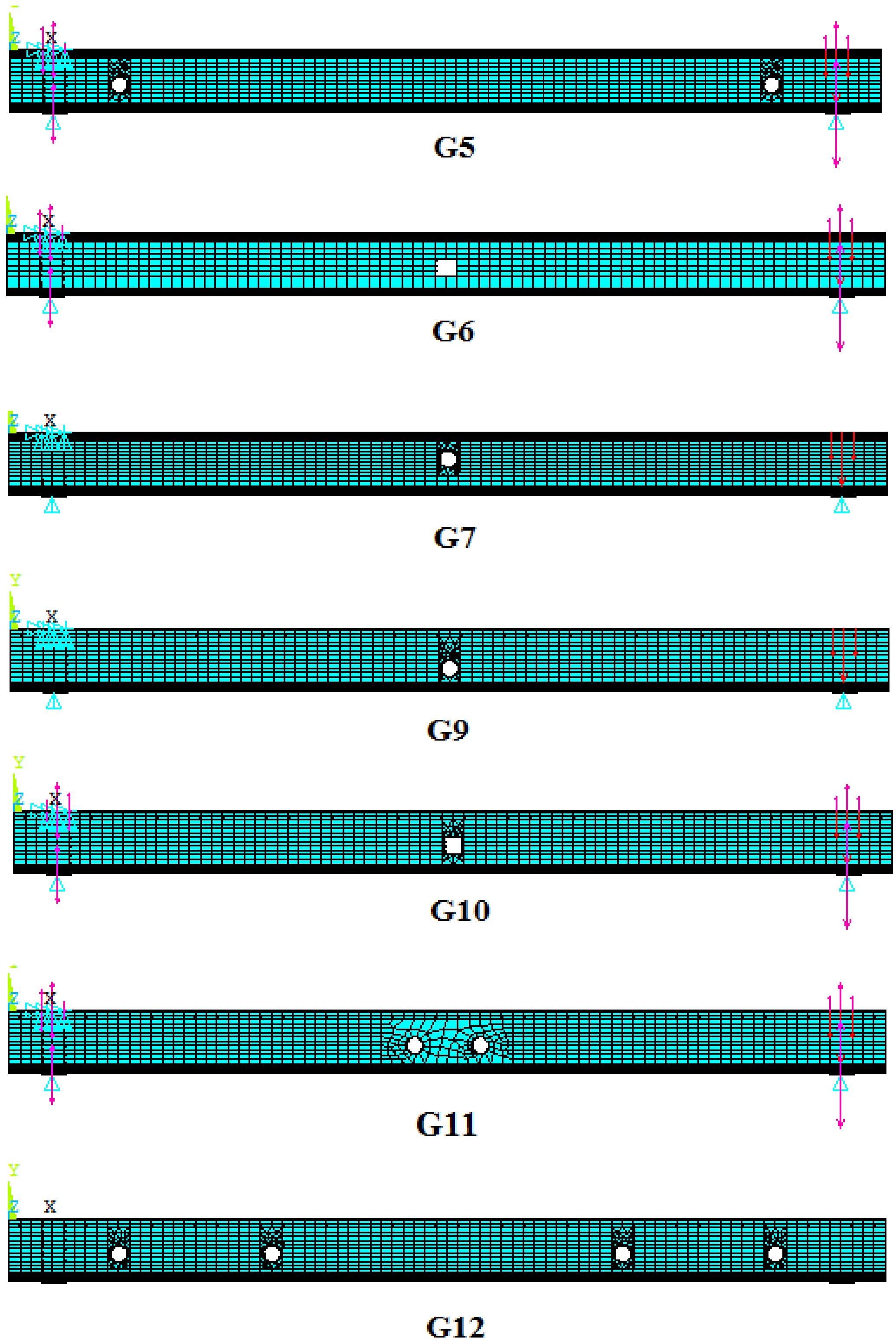


Figure 4b. Model program G5, G6, G7 and from G9 to G12.

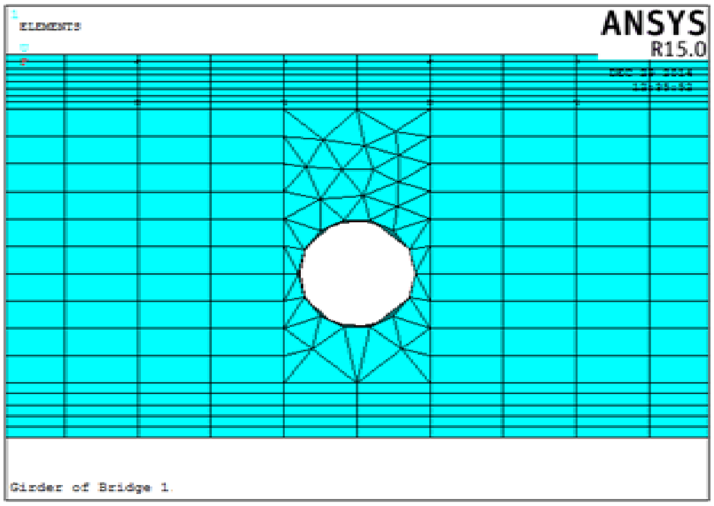


Figure 5. Square or rectangular and tetrahedron mesh were used.

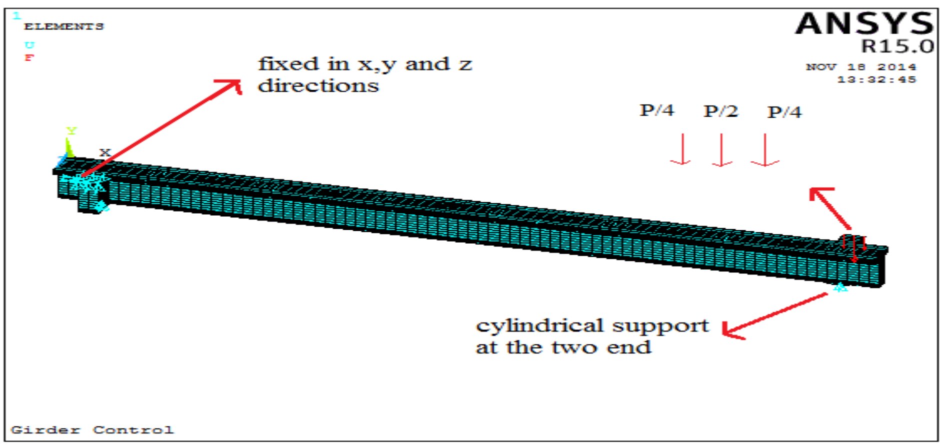


Figure 6. Loading and boundary conditions of CG used in the analysis.

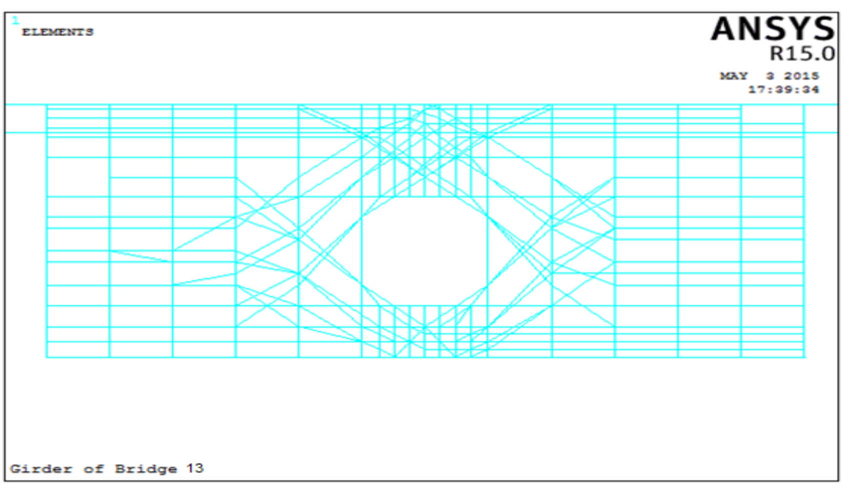


Figure 7. Additional reinforcement of T-girder G13.

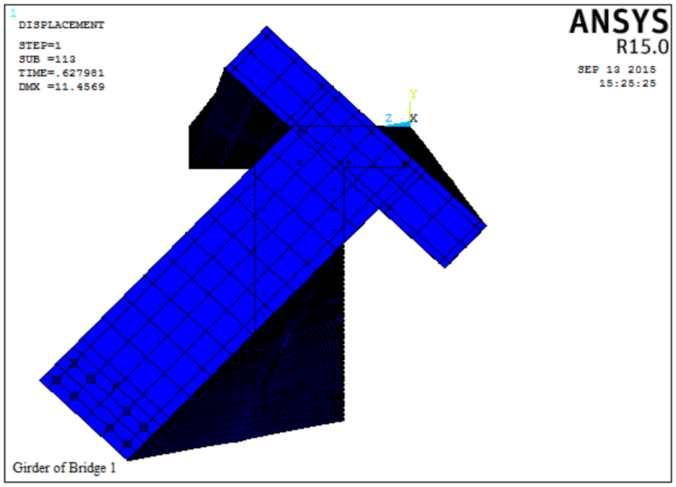


Figure 8. The deformed shape of the control girder CG.

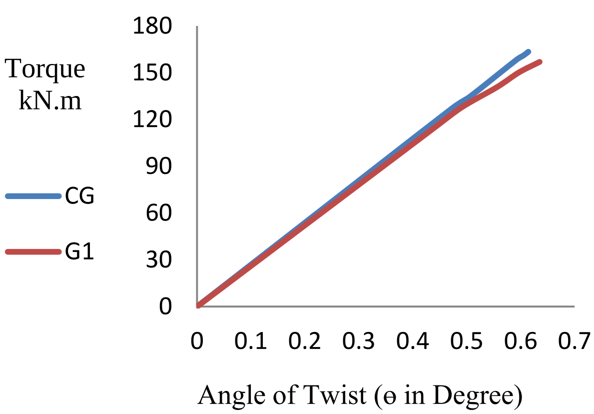


Figure 9. Torque-twist behavior for G1.

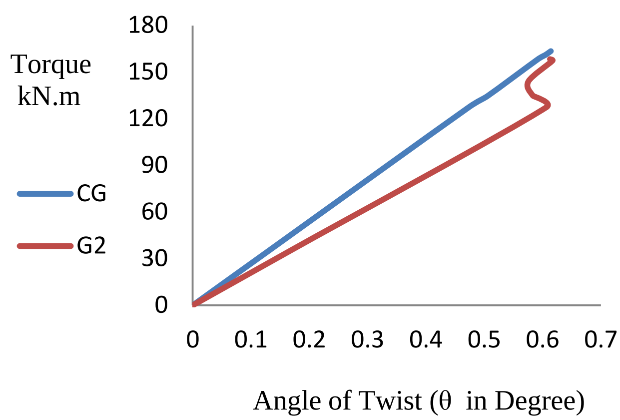


Figure 10. Torque-twist behavior for G2.

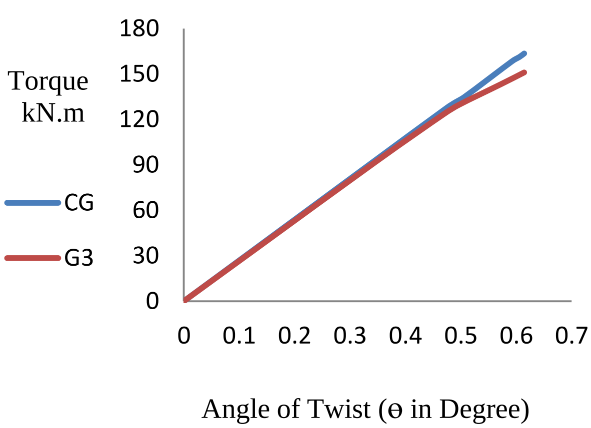


Figure 11. Torque-twist behavior for G3.

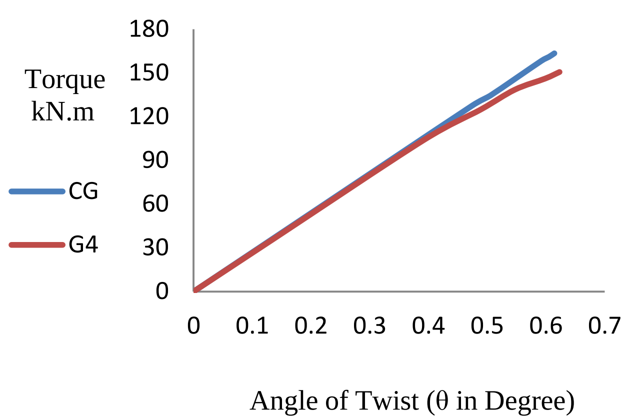


Figure 12. Torque-twist behavior for G4.

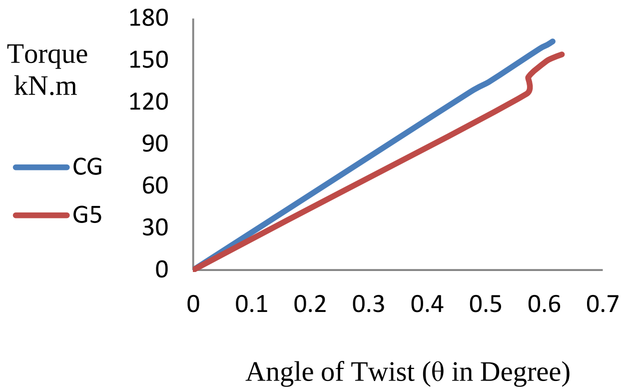


Figure 13. Torque-twist behavior for G5.

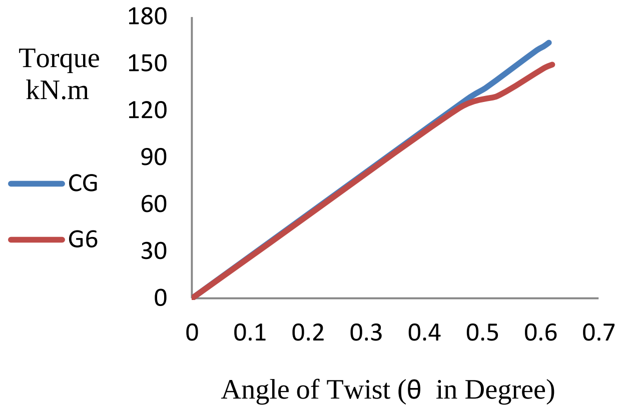


Figure 14. Torque-twist behavior for G6.

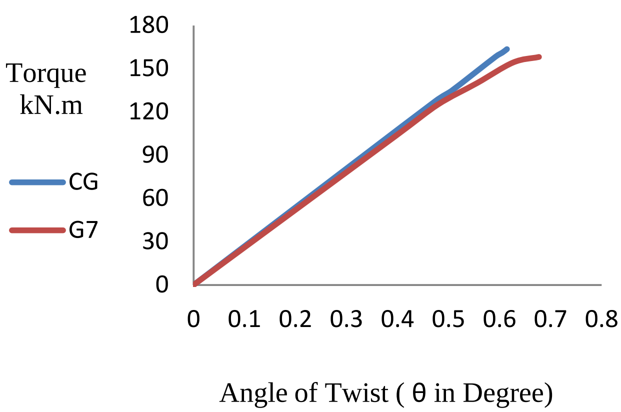


Figure 15. Torque-twist behavior for G7

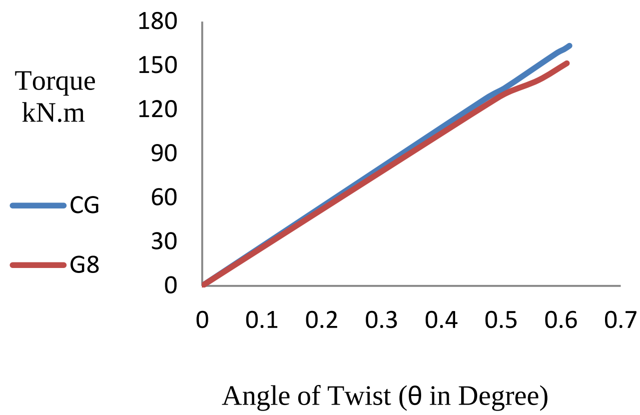


Figure 16. Torque-twist behavior for G8**.**

Figure 17. Torque-twist behavior for G9.

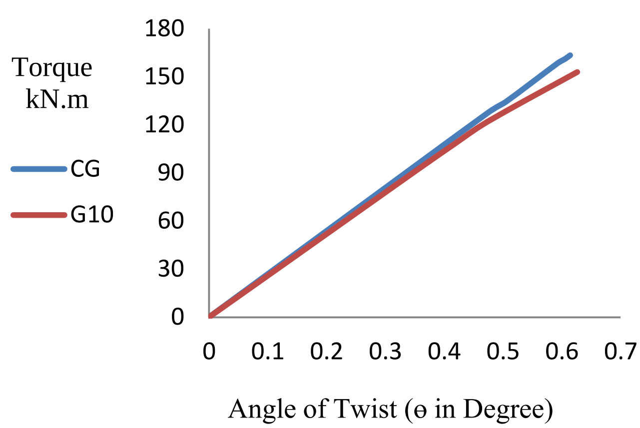


Figure 18. Torque-twist behavior for G10.

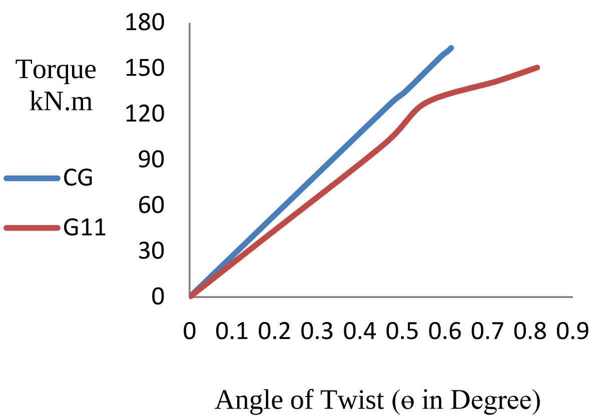


Figure 19. Torque-twist behavior for G11.

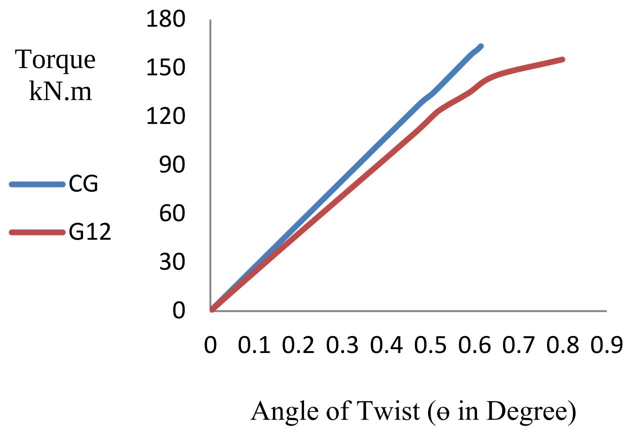


Figure 20. Torque-twist behavior for G12.

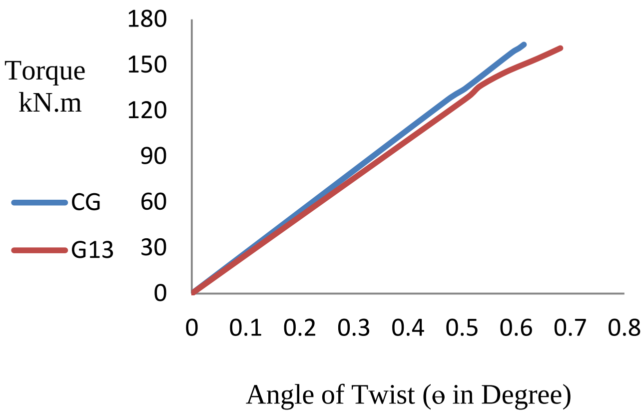


Figure 21. Torque-twist behavior for G13.

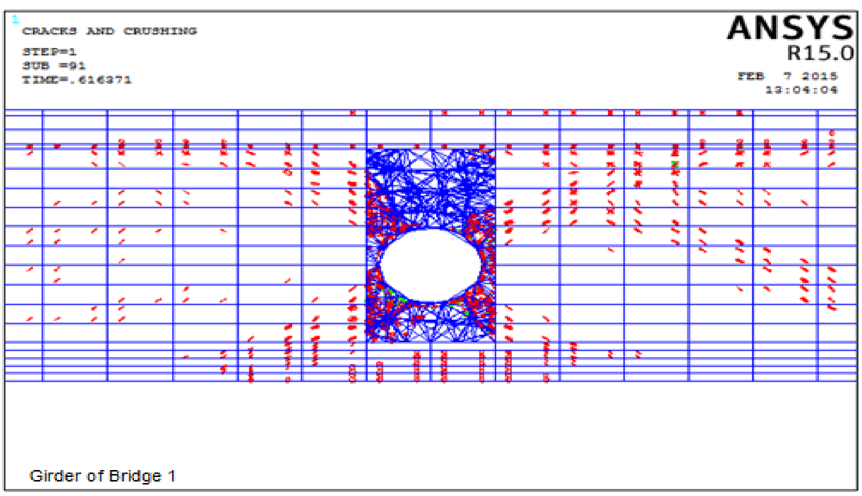


Figure 22. Numerical crack patterns around an opening.

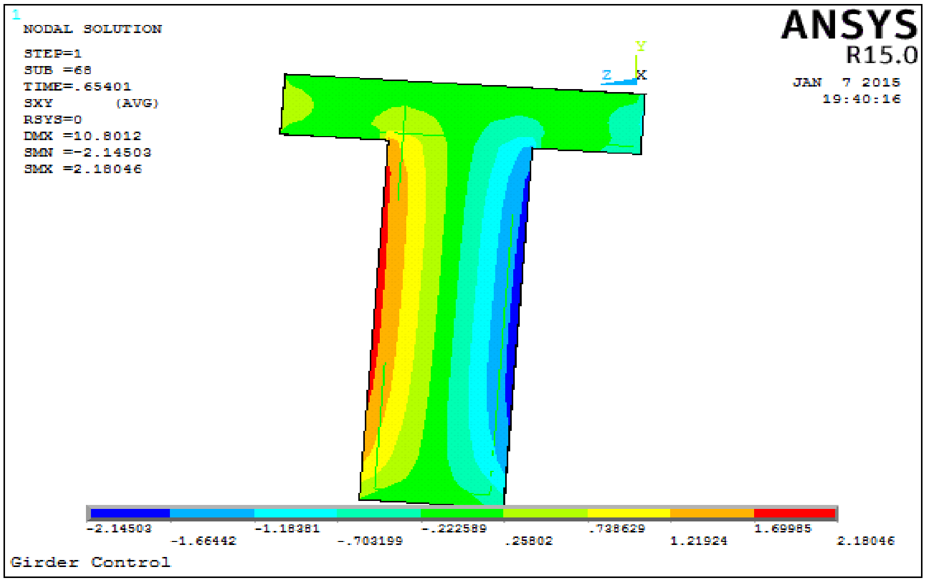


Figure 23. Numerical XY-shear stress patterns for CG.

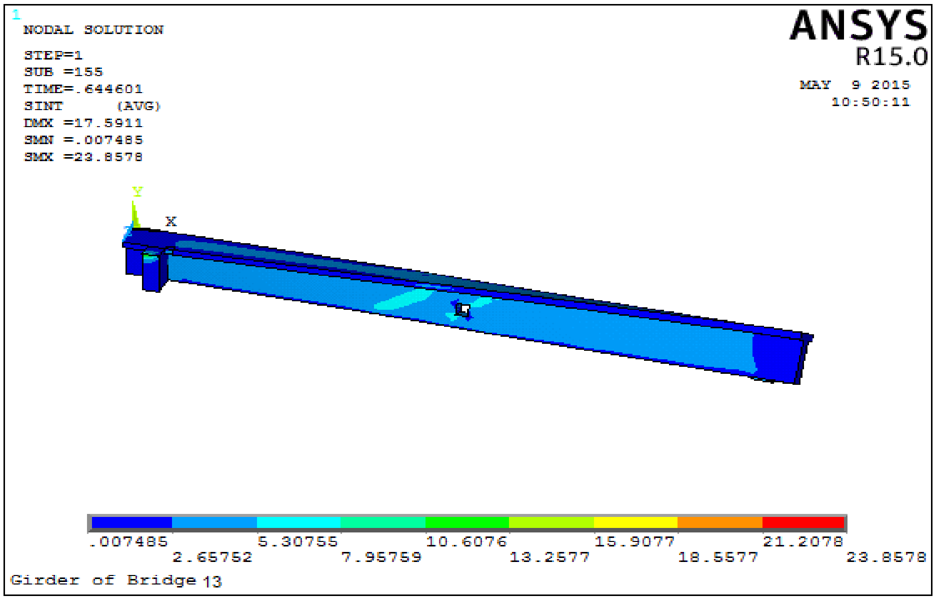


Figure 24. Numerical stress intensity of the reinforced concrete for G13**.**

Table 1.T-girders used in the modeling program.

Girder Symbol	Description
CG	Control T-girder (without web openings)
G1	T-Girder with one circular web opening at the center of the T- girder (D = 400 mm)
G2	T-Girder with one circular web openings at 1050mm from the supporting end arm of the T-girder (D = 400 mm)
G3	T-Girder with one equivalent square web opening at the center of the web (L = 360 mm)
G4	T-Girder with one circular web opening at the center of the girder (D = 600 mm).
G5	T-Girder with two circular web openings at 1050mm from the two end arms of the girder (D = 400 mm.)
G6	T-Girder with one rectangular web opening at the center of the web (L = 500 mm, H = 400 mm).
G7	T-Girder with one circular web opening with eccentricity 200 mm above the center of the web girder (D = 400 mm).
G8	T-Girder with one equivalent square web opening at the center of the web (L = 360 mm) strengthen with additional reinforcement.
G9	T-Girder with one circular web opening with eccentricity 200 mm under the center of the web girder (D = 400 mm).
G10	T-Girder with one square web opening at the center of the web (L= 400 mm).
G11	T-Girder with two circular web openings near the center of the web (L= 400 mm) and the distance between the openings is 1100 mm.
G12	T-Girder with four circular web openings near the loaded arms (L= 400 mm) and the distance between the two adjacent openings is 3100 mm.
G13	T-Girder with one equivalent square web opening at the center of the web (L = 360 mm) with increasing the additional strengthen reinforcement.

Table 2. Summary of numerical torque results.

Model Specimen	**First Cracking Torque (kN.m)**	**Ultimate Torque (kN.m)**	**%Reduction in Ultimate Torque**	**Angle of Twist at Failure (ɵ in degree)**
CG	125.6450	163.5025	-----	0.614300
G1	102.1525	156.9950	% 3.980	0.635273
G2	125.6450	158.3625	% 3.144	0.612762
G3	113.205	150.9825	% 7.657	0.614229
G4	102.1525	150.6600	% 7.854	0.623128
G5	125.6450	154.1950	% 5.693	0.630033
G6	121.3725	149.4750	% 8.579	0.620090
G7	102.1525	158.0925	% 3.310	0.677114
G8	103.9025	151.5700	% 7.298	0.609854
G9	113.2050	152.1772	% 6.927	0.613281
G10	82.9300	153.0050	% 6.420	0.626393
G11	100.230	150.6375	% 7.868	0.816267
G12	102.1525	155.2725	% 5.000	0.799121
G13	107.7950	161.1500	% 1.440	0.681792

Number 2 Volume 22 February 2016 Journal of Engineering

المدينة الايكولوجية الصديقة للبيئة

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الخلاصة

شَهدَ العالم خلال العقود القليلة الماضية تغيراً واضحاً في خارطة الوجود الحضري, حيث أزداد عدد سكان المدن و توسعت رقعتها الجغرافية وأنتشرت شبكات الطرق الرصاصية و محطات توليد الطاقة الكهربائية. تسببت هذهِ الظواهر الاستثنائية في رسم هوية مغايرة للعالم الحالي, ليصبح عالم يتسابق مع نفسهِ في مجال إستهلاك الطاقة و المواد الاولية. تركزت مشكلة البحث العامة في قلة الدراسات المتوفرة بخصوص موضوع التخطيط و التصميم الحضري الايكولوجي الصديق للبيئة. بالتالي يهدف البحث بشكل عام الى تحديد مقومات بنية المدينة الايكولوجية الصديقة للبيئة و من ثم الى توضيح أهم الأسس التخطيطية و التصميمية لتلك المقومات. يفترض البحث في ضوء ذلك أن تطوير التجمعات الحضرية الحالية و المستقبلية نحو تجمعات أيكولوجية صديقة للبيئة الطبيعية يعتمد على إيجاد بنية حضرية متكاملة قائمة على عدد من الاسس و المعايير المستلهمة في الاساس من صفات الانظمة الايكولوجية في تلك البيئة الطبيعية.

الكلمات المفتاحية: الإستدامة الحضرية, البيئة الطبيعية, التحضر, النظام الايكولوجي, التنطيق الايكولوجي الوظيفي.

Environment Friendly Eco - City

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ABSTRACT

The World witnessed over the past few decades a clear change in the urban existence map, where the number of cities' residents has increased and the cities geographic area expanded, also networks of roads and electric power stations were spread. This extraordinary events caused the drawing of a different identity to the world, race with itself in the field of energy and raw materials consumption. Therefore, the research issue individualizes in the lack of available knowledge concerning the subject of environment friendly ecological urban desiging and planning.So the research aims to define the environmentally friendly eco-city' structural elements and to clarify their most important planning and design foundations. To Investigative this goal the research has assumed that "the human urban agglomerations' development towards environment friendly ecological ones would depend on finding a complete urban structure grounded on a numbers of foundations and standards which are basically inspired from the qualities of systems in such natural environment".

Key words : urban sustainability, Natural environment, urbanism, ecological system, functional ecological zoning .

المـــقدمـــة

توجهت الإدارات التخطيطية الحضرية لعددٍ كبيرٍ من أكثر دول العالم تقدماً عمرانياً و إقتصادياً نحو التأكيد على ضرورة إعتماد مفاهيم الإنشاء الحضري الصديق للبيئة كأساس في إنتاج مدن المستقبل التي تضمن حق الانسان و الطبيعة على السواء في الاستمرار و البقاء. يُعد طرح المدينة الايكولوجية الصديقة للبيئة أحد التوجهات العمرانية المستدامة و ذلك على مستوى التصميم و التخطيط الحضري للمستوطنات البشرية. لذا فأن البحث الحالي يهدف الى تحديد مقومات بنية المدينة الايكولوجية الصديقة للبيئة و الى توضيح أهم أسسها التخطيطية و التصميمية المعتمدة على مبادىء الايكولوجيا الحضرية، و ذلك بإعتماد منهج علمي وصفي تحليلي تتطور بنيتهُ العامة وتتقدم مع ما تتوصل اليهِ نصوصهُ من حقائق وإستنتاجات مرحلية.

1- المشكلات البيئية التي واجهت تخطيط المدينة الحديثة

و المقصود هنا بالمدينة الحديثة هي المدينة التي ظهرت بعد قيام الثورة الصناعية النفطية في نهايات القرن التاسع عشر و بداية القرن العشرين. إذ أمتلكت المدينة بعد هذهِ الثورة بُعداً تكوينياً جديداً, فلم يعدّ الإمتداد الافقي هو الدلالة الوحيدة لنموها وتوسعها ولم يعدّ المسكن المكون من طابق واحد او طابقين هو الوحدة الأساسية لها, إذ أمتلكت المدينة بعداً عمودياً جديداً تمثل بناطحات السحاب صعوداً, و ألانفاق تحت الارضية نزولاً. وقد أمتدت مقاييس المدينة بعد قيام الثورة الصناعية النفطية لتحتوي الحجم فضلاً عن المساحة حيث ظهرت بعض المستويات الرأسية تحت الارضية التي أحتوت على وظائف مهمة وحيوية, مثل البنى التحتية الخدمية وأنفاق السير و الحركة وغيرها الكثير (Shane D.G. ,2011,pp217-219). أستمرت المدينة في النمو المضطرد وبالإتجاهين الافقي والعمودي ليكونا معاً ما يُعرف اليوم عالميا بـ(المدن العملاقة - Mega-cities), وهي المدن التي يزداد عدد سكاّنها عن (10مليون) نسمة (FIG REPORT,2010,p21). و يمكن إيجاز أهم المشكلات البيئية التي واجهت تخطيط المدينة بعد قيام الثورة الصناعية ولا سيما النفطية منها بثلاث مشكلات أساسية, وهي كما يأتي :

أ) ظاهرة التحضر: و المقصود بها ظاهرة زيادة حركات الهجرة وإندفاع سكان الارياف بأتجاه مراكز المدن (Rees W. & Wackernagel M. ,1996, p223). لقد بلغ عدد سكان المدن (3.3 بليون) نسمة في العام 2007 أي نحو نصف عدد سكان العالم, ومن المتوقع أن يتضاعف هذا العدد وصولاً الى (6.4 بليون) نسمة في عام 2050 (Head P. & Lam D. ,2011, p18).

ب) إستهلاك مصادر الطاقة الناضبة : إرتبط مع الإرتفاع الهائل في عدد سكان المدن ومع التطور الكبير الحادث في الانماط الحياتية المعاشة إرتفاعاً كبيراً في معدلات إستهلاك المدن للطاقة التي باتت تتجاوز نسبة (1 - 2) من قدرة النظم الطبيعية الموجودة ضمن مواقعها على دعم الإنسان فيها (Grimm N. ,2010 ,p12).

ج) التغيير المناخي : لقد شهد القرن العشرين بمفردهِ إرتفاعاً في درجة حرارة الارض بنحو (0.74درجة مئوية), و ضعفاً في الغطاء الجليدي بنسبة (40%), وإزدياداً في الامطار الحامضية, و إرتفاعاً في مناسيب مياه البحر والمحيطات نحو (17 سم) (Berthold J. & Wetterwik M. ,2013, P4 ,P2). ومن هذه الارقام يمكن تخيل الضغط الكبير الذي تُعانيه البيئة الطبيعية حالياً؛ بسبب التطور الصناعي والتقني لأنشطة الإنسان و نتاجاتهِ الحضرية.

2- المدينة الايكولوجية ..... مصطلحات و أهداف

ظهرت مجموعة واسعة من التعاريف الشاملة لمعنى (المدينة الايكولوجية) أكدت معظمها على التكامل بين جميع جوانب الحياة في المدينة بما لا يضر بالبيئة الطبيعية المحيطة, وبما يحقق مبدأ (الاستدامة الحضرية). كان أحد أهم هذه التعاريف هو التعريف الذي قدمتة منظمة (Ecocity Builders)* الذي يُعدّ الاكثر شمولاً و وضوحاً في تحديد أهداف وغايات ايجاد المدينة الايكولوجية. فقد عرفت هذه المنظمة التي تُعدّ الاولى في مجال التخطيط الحضري الايكولوجي المدينة الايكولوجية في العام 2009 على أنّها " مستوطنة بشرية مصممة على إنموذج الاكتفاء الذاتي والهياكل المرنة واحتواء وظائف الانظمة الايكولوجية الطبيعية, حيث توفر هذهِ المستوطنة الراحة الصحية لساكنيها بدون استهلاك الطاقات المتجددة أكثر مما يمكن أن تنتج, وبدون أنتاج النفايات أكثر مما يمكن أن تستوعب, وبدون أن تصبح سامة لنفسها أو للانظمة الايكولوجية المجاورة لها. يعبر التأثير الايكولوجي لساكني هذهِ المدينة عن الانماط الكوكبية الداعمة للحياة, كما يعبر نظامها الاجتماعي عن المبادىء الاساسية للنزاهة والعدالة والانصاف المعقول " (Ecocity builder org. ,2009,p8).

يقول الباحث (Tim Smith**) ان " الاستدامة تمتلك أجهزة صلبة وبرمجيات (hardware & Software), وأن البيئة المبنية والحدائق وكل الاشياء التي يمكن لمسها هي جزء من الاجهزة (hardware), في حين تشكل البرمجيات (software) شبكة الانظمة التي تُحرك تدفقات الطاقة و الموارد و رأس المال والمعلومات خلال المدن والاقاليم, و أن التقارب بين هذين الامرين هو في الواقع (المدينة الايكولوجية) أو ما يمكن أن تكون " (Smith T.,2009,p1). و بذلك يمكن تعريف (المدينة الايكولوجية) على أنّها " **تأمين وجود حضري مريح لساكنيهِ غير ضار ببيئتهِ الطبيعية؛ وذلك عن طريق تحديد معدلات تشغيلهُ بما لايتجاوز قدرة موقعهِ الطبيعية على دعمهِ الحيوي, وبما لايضرها او يستهلك مكونات أنظمتها الايكولوجية الحيوية وغير الحيوية . يتضمن أساس خطوات أيجاد هذهِ المدينة توظيف فكرة تشغيلها كنظام أيكولوجي ذاتي ومرن**", أي ان "**المدينة الايكولوجية هي مدينة تحافظ على الانظمة الايكولوجية في الطبيعة وتعمل بنفس ميكانيكتها**".

3- الفلسفة التخطيطية العامة للمدينة الايكولوجية

تعتمد المدينة الايكولوجية في تحقيق أهدافها العامة وفي حل المشكلات البيئية المذكورة أنفاً فلسفةً تخطيطيةً خاصةً تؤكد على فهم ميكانيكية عمل الانظمة الايكولوجية الطبيعية, ومن ثم محاولة محاكاتها من حيث الفكر والطريقة في عمليات التخطيط الحضري (Williams D.E.,2007). علماً أن (النظام الايكولوجي) هو كل ما تحتويه قطعة أرض مهما كان حجمها من العناصر الحية وغير الحية فضلاً عما تشملهُ من تفاعلات وعمليات تتم داخلها أو بينها وبين ما يحيط بها من

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* منظمة (Ecocity Builders) : منظمة مروجة لمبادىء الايكولوجيا الحضرية أسسها المعماري الامريكي (Richard Register) في عام 1992 , حيث أدارت هذه المنظمة شبكة دولية من المؤتمرات العلمية المتحورة بخصوص (المدينة الايكولوجية) و ستراتيجيات تطبيقها. وقد وفرت هذه المؤتمرات فرصاً حقيقية للتعرف على أصول التصميم الحضري الايكولوجي المنسجم مع الطبيعة, فضلاً عن إمكانية مشاركة الخبرات لافضل الاكتشافات البيئية حول العالم (Register R.,2007, pp239-240, pp 2-1) .

** Tim Smith : - رئيس جمعية (SERA) الامريكية للمهندسين المعماريين ومخطط معتمد ومهندس مشهور لأكثر من (30) عاماً من الخبرة المهنية . يتبوء (Smith) العديد من المهام منها: تدريسهُ التخطيط والتصميم في عدد من الجامعات, وتقديمهُ لمحاضرات عدة عن مدن الاستدامة النقلية (TOD- transport oriented development), وتنشيط القرى القائمة وزيادة ديمومتها ,كما أنهُ حاصل على العديد من الجوائز عن نشاطهِ في مجال النمو الذكي للمدينة الحديثة.

بيئة خارجية (Grimm N.,2010,p3,p2). قدم المفكر الايكولوجي (Howard T. Odem)* إنموذجاً يوضح سلوك الانظمة الايكولوجية الطبيعية عن طريق توضيح العلاقة بين تدفقات الطاقة والمواد و بين مكونات النظام وبين المنتجين والمستهلكين ضمنها. أكد هذا الإنموذج على إمكانية تغيير العلاقة بين مكونات النظام الايكولوجي عن طريق تغيير الارتباطات والتدفقات بينها (شكل1) . يساعد إنموذج (Odem) هذا على إدراك ميكانيكية العمل ضمن النظام الايكولوجي الطبيعي؛ لانهُ يشرح العلاقات والارتباطات البسيطة و الاساسية بين الطاقات الطبيعية و الموارد المتجددة, و بما أن تحقيق الاستدامة يرتبط باستخدام الموارد المحلية المتجددة, فإنّ هذا الإنموذج يشرح و يحدد الفرص والعلاقات التي تحتاج الى عمليات التصميم البينية اللازمة لتحقيق الاستدامة الحضرية الايكولوجية (شكل2) (Williams D.E., 2007,p3,p1). تؤدي الملاحظة المستمرة لهذا الإنموذج الى إدراك سيطرة مبدأ (الاستدامة) على جميع التدفقات داخل الانظمة الايكولوجية الطبيعية, حيث تنتج هذهِ الاستدامة من الشمس بالدرجة الاولى؛ وذلك لانها تُعدّ المصدر الرئيس للطاقة المتجددة في الطبيعة, ومن ثم فإنّ (الاستدامة) تنتج من تكاملية العلاقات بين مكونات هذهِ الانظمة . تعتمد فلسفة تخطيط المدينة الايكولوجية على فهم إنموذج (Odem), وترجمتهُ بما ينطبق مع عمليات تخطيط وتصميم المدينة كجزء من الطبيعة (أي مع نظرية عدّ المدينة نظاماً أيكولوجياً متكاملاً), وبذلك فإنّ الفكرة الرئيسة للمدينة الايكولوجية تعتمد على تغيير طريقة تدفق المواد والطاقة بين مكوناتها الاساسية و بيئتها المحيطة بما يتشابه مع الطريقة المستدامة الموجودة ضمن الانظمة الايكولوجية في الطبيعة.

1-3 الانظمة الايكولوجية الطبيعية

تعتمد فلسفة تشغيل المدينة الايكولوجية على محاكاة النظم البيئية الطبيعية الناضجة أيكولوجياً ** و التشبه بها, كما أنها تسعى للحفاظ على باقي أنواع النظم البيئية الموجودة في الموقع (Covington W. & DeBano F.,1993,p150). تتميز هذهِ النظم بعدد من الخصائص التي تكون الاساس في تحديد خصائص المدينة الايكولوجية الصديقة للبيئة ومنها :

1- الصحة (الفعالية) - Healthy (Effective) : تستطيع النظم الايكولوجية في الطبيعة إعالة نفسها بشكل فعال, والبقاء بصحة جيدة عن طريق إلتقاط و تخزين ما يكفيها من الطاقة والمواد لتلبية جميع احتياجاتها الحيوية (Newman P. & Jennings I., 2008,p95,p3).

2- التنظيم الذاتي (Self-Regulation) : يشمل أداء أي نظام أيكولوجي في الطبيعة على وجود حلقات من ردود الفعل المرتدة التي تساعده على تنظيم نفسه, والحفاظ على أدائهِ الطبيعي, لا سيما بعد حدوث الاضطرابات والتغييرات المفاجئة في البيئة المحيطة . تقسم ردود الافعال في الطبيعة الى نوعين أيجابية وسلبية, الاولى تحفز على التغيير في عمل النظام الايكولوجي, وهي السبب الرئيس في حدوث العديد من المشكلات البيئية والتغييرات السريعة في العالم, في حين أن الثانية توفر الاستقرار, وبالتالي فأنّ ردود الفعل السلبية هي أكثر أهمية في التنظيم الذاتي, ولا سيما إنّها تُبقي الانظمة ضمن حالة من التوازن المستمر (Marten G. ,2001,p17-20).

3- عدم أنتاج النفايات (Zero Waste) : تتميز شبكة النظم الايكولوجية الطبيعية باحتواءِها على سلسلة من الدورات البيولوجية المتاحة التي توفر المواد الغذائية للكائنات الحية, والتي تتميز بقدرتها على معالجة النفايات الناتجة عنها . ففي

* Howard T. Odem : هو هوارد توماس اودم، عالم امريكي متخصص بالعلوم الايكولوجية ولد في عام 1924 و توفي في عام 2002 تاركاً إرثا كبيرا من المؤلفات في العديد من المجالات المرتبطة بمواضيع الايكولوجيا و النظم وإنتاج الطاقة (http://en.wikipedia.org/wiki/Howard_T._Odum).

**النظم الناضجة ايكولوجياً: وهي النظم غير المتأثرة بالفعاليات الأنسانية كالغابات والصحارى وغيرها , وهي ذات تنوع حياتي عالي جداً (أكرم العكام و إيناس العاني, 2009,ص15,ج2).

الطبيعة يتم انتاج النفايات عن طريق الكائنات الحية (النباتات والحيوانات والناس) إلاّ أنّ هنالك كائنات أخرى تتغذى على هذه النفايات المتمثلة بمخلفات الانسان الطبيعية واوراق الشجر والجثث الميتة, ومن ثم فإنّ الكائنات في الطبيعة تعتمد على بعضها البعض في التغذية, و في تطهير النظام من أية نفايات ناتجة عنها (Newman P. & Jennings I., 2008,p97,p3).

4- المرونة (Flexibility): يتميز هيكل شبكة الانظمة الايكولوجية الطبيعية باللامركزية, مما يسهل حدوث ردود الافعال الايجابية والاستجابات المرنة لأحدى الانظمة دون أحداث تأثيرات في بقية الانظمة المرتبطة معها (Newman P. & Jennings I., 2008,p102,p2).

2-3 المدينة كنظام أيكولوجي طبيعي

تمتلك المدينة بوصفها نظاماً أيكولوجياً لمنظومة واسعة من المدخلات والمخرجات المتعددة و التي يمكن التعبير عنها عن طريق إنموذج " الايض الحضري", إذ يعبر هذا الإنموذج عن "عمليات التبادل المستمرة التي تجري بين المدينة وأنظمة دعمها, أي البيئة المحيطة بها والتي تعتمد على طريقة إدارة المدينة لنظامها اليومي من الاحتياجات والمخلفات" (Vieiran S. & Bragança L.,2012,p2,p1) . يتجاوز مبدأ الأيض الحضري الايكولوجي الموسع مبادىء التخطيط الحضري السابقة المعتمدة على دراسة الفروق بين الطلب البشري و العرض الطبيعي على المواد الإستهلاكية الخام ليصل الى مبدأ أكثر شمولية يعتمد على اضافة الانظمة البشرية والإجتماعية والسياسية والإقتصادية وغيرها من أنظمة المدينة الى معادلة الطلب والعرض السابقة (Grimm N. ,2010,p4,p1). تفضي حقيقة عدّ المدينة نظاماً أيكولوجياً متكاملاً مشابهاً لذلك الموجود في الطبيعة الى إتصاف هذهِ المدينة بعدد من الخصائص المستلهمة في الاساس من صفات الانظمة الطبيعية الناضجة أيكولوجياً (Su m. & et al ,2013,p5,p2):

1- الصحة والانسجام (Healthy & Harmony) : تتميز أنظمة الدعم البشرية في المدينة الايكولوجية بالصحة والاستدامة, مما يمكنها من تقديم كمية كافية وثابتة من خدمات الانظمة الايكولوجية.

2- الكفاءة العالية و الفعالية (High Efficiency & Vigor): تؤكد المدينة الايكولوجية على ضرورة تغيير أنماط التنمية المتميزة بـ(الاستهلاك العالي) و(الانبعاث العالي) و(التلوث العالي) و(الانتاج المنخفض) الى أنماط تنمية أكثر صداقة للبيئة, حيث تُستخدم الطاقة والمواد على سبيل المثال في المدينة الايكولوجية بكفاءة عالية وذلك عن طريق تخطيط وتصميم جميع الصناعات والادارات في علاقة تعاونية منسجمة مع بعضها.

3- التوجه منخفض الكاربون (Low Carbon Orientation): تفرض شروط مواجهة التحدي الحاضر المتمثل بالتغيير المناخي التأكيد على تنمية منخفضة الكاربون التي يمكن أن تتضح عن طريق زيادة أنتاجية المصادر, وكذلك عن طريق تطوير تكنولوجيا رائدة, و خلق أعمال و وظائف جديدة صديقة مع البيئة.

4- ادامة الازدهار (Sustaining Prosperity): يؤدي عدّ (التنمية المستدامة) المبدأ التوجيهي الاساس في المدينة الايكولوجية الى اعتماد الاستخدام المنطقي للموارد على المستويين الزماني والمكاني, بمعنى أخر فإنّ تنمية الجيل الحالي لن تُعرض تنمية الجيل المستقبلي للخطر حيث سيستمر الازدهار في المدينة الايكولوجية.

4- مقومات بنية المدينة الايكولوجية

أكدت سلسلة الكتب التي أطلقها مجموعة من المختصين في مجال التحضر الايكولوجي وهم (Philine Gaffron) و (Gé Huismans) و (Franz Skala) تحت عنوان " Ecocity Book " أن لبنية المدينة الايكولوجية عدد من المقومات الاساسية

التي يجب العمل ضمنها و وفقها, وهي التعامل مع المحيط الايكولوجي و البيئة المبنية والنقل والطاقة وتدفق المواد. وقد اتفق على هذا الطرح أغلب الدراسات و البحوث التي تناولت موضوع مقومات تخطيط المدينة الايكولوجية ومن هنا يجد البحث ان هنالك خمسة مقومات أساسية لبنية المدينة الايكولوجية, وهي (السياق الطبيعي والحضري) و (البنى الارتكازية الخضراء) و (البيئة المبنية) و (النقل) و (الطاقة و تدفق المواد). يتعلق المقوم الاول بتوضيح كيفية إختيار الموقع المناسب لانشاء المدينة الايكولوجية من الناحيتين الطبيعية والحضرية, في حين تتعلق باقي المقومات الاربعة في توضيح كيفية تخطيط وتصميم قطاعات التنمية الحضرية ضمن المدينة الايكولوجية, إذ تنطوي كل من هذهِ المقومات على عدد من الاسس والاهداف والمكونات وسبل التحقيق الا أن أهم ما يميزها مجتمعةً هو إن معظمها يصبو الى تحقيق الاهداف نفسها ولكن بإستخدام طرق و إليات مختلفة تعتمد جميعها في تكوينها على الفلسفة التخطيطية العامة للمدينة الايكولوجية.

1-4 مقوم السياق الطبيعي والحضري وأسسهُ التخطيطية والتصميمية :

يؤكد هذا المقوم على ضرورة مراعاة خصائص السياق الطبيعي المتمثل بـ(البيئة الايكولوجية), والسياق الحضري المتمثل بـ(البيئة المبنية) في إختيار الموقع الامثل للمدينة الايكولوجية الصديقة للبيئة. يهدف هذا المقوم الى حماية البيئة الطبيعية الايكولوجية المهمة من آثار عمليات التنمية الحضرية (Gaffron P. ,2005,p19,p4). يمكن إستخدام منهجية (التنطيق الايكولوجي الوظيفي) للتعرف على السياق الطبيعي للموقع, ومدى ملائمتهِ لانشاء تجمع حضري أيكولوجي ضمنهُ. يتطلب القيام بعملية تنطيق وظيفي ايكولوجي إجراء عملية في غاية الدقة , تتمثل بإجراء مسح ميداني في الخطوة الاولى؛ وذلك من أجل فهم الوضع الحالي للبيئة الايكولوجية للموقع المتمثل بالطوبوغرافية والجغرافية, واستعمالات الارض والغطاء النباتي وغيرها. أما الخطوة الثانية فتتمثل باجراء تحليل مفصل للمشكلات الايكولوجية الرئيسة, وللصفات التي تتميز بها الانظمة الايكولوجية المحلية التي تمكنها من إستيعاب هذه المشكلات, إذ يكون الهدف من هذه الخطوة هو تحديد درجة حساسية المناطق للتدخلات البشرية (درجة التغير المحتمل حصولها). تتمثل الخطوة الاخيرة بتحديد نوع المنطقة الايكولوجية؛ وذلك حسب تحليل الحساسية السابق والقدرة الاستيعابية للانظمة الايكولوجية وقيمة خدمات الانظمة الايكولوجية (شكل 3). إذ تقسم منهجية التنطيق الوظيفي مناطق الدراسة الى (اربع) مناطق أيكولوجية رئيسة وهي كالأتي (Tain G. & Zhang L.,2013,pp107-112) :

- **المنطقة محظورة التنمية (Development-Prohibited Zone)**: وهي أكثر المناطق حساسية للتدخلات البشرية, حيث تشمل المحميات الطبيعية الوطنية والمواقع الثقافية والطبيعية و التراثية و المتنزهات الرئيسة الوطنية, وهي ضرورية جدا لضمان الامن البيئي الايكولوجي للمنطقة بأكملها لذلك فهي تمثل (خطاً أحمراً) في عملية التنمية الحضرية عن طريق التأكيد على فكرة الحفاظ عليها ومنع الانشاء فيها بتاتاً.
- **المنطقة مقيدة التنمية (Development-Restricted Zone)**: وهي المناطق ذات الموارد والهبات الطبيعية الضعيفة, والتي تمتلك شروطاً فقيرة في مجال الإقتصاد والإسكان إلّا أنّها حاسمة وضرورية في توفير الآمان الايكولوجي في منطقة أوسع أو عبر الاقليم بأكمله. تتميز هذه المناطق بأنّها حساسة للنشاط البشري, وتمتلك تأثير كبيراً في البيئة الايكولوجية الاقليمية, بالتالي فهي تفرض ضرورة إنسجام عمليات التنمية والتطوير مع قدرتها الاستيعابية وعدم تجاوزها.
- **المنطقة المثلى للتنمية (Development-Optimized Zone)** وهي الاقاليم التي تعرضت الى كثافة عالية في عملية التطوير البشري, ولا سيما الصناعي منها مما أدى ذلك الى اضعاف مواردها وهباتها البيئية, حيث يجب تركيز الاهتمام بها على نوعية وفائدة التحسينات المضافة لها والنهوض بمستواها الادائي الحالي.

- **المنطقة ذات الاولوية في عملية التنمية (Development-Prioritized Zone)**: أو مناطق التنمية الرئيسة وهي أقل المناطق حساسية للتدخلات البشرية, حيث تتميز بإمتلاكها لموارد قوية نسبياً و هبات بيئية عدة ولكنها مستخدمة بنسبة قليلة؛ وبذلك فهي أكثر مناسبة لعمليات التنمية و إيجاد تجمعات إقتصادية و إسكانية مستدامة ضمنها, و يكون التركيز بها في إستخدام أفضل ما هو موجود من البنى التحتية و الاستثمار البيئي والقطاعات التطويرية الصناعية والاقتصادية.

أما فيما يخص مراعاة السياق الحضري في إختيار موقع المدينة الايكولوجية, فيسعى هذا المقوم لإختيار أكثر المواقع مناسبة لإنشاء هذهِ المدينة , حيث يجب أن يوفر الموقع المختار لها المواصفات الحضرية الاساسية لتحقيق الأهداف الاتية (Gaffron P. ,2005,p20,p2):

- إيجاد نظام نقل عام جذاب ومريح يتيح أقصى قدر ممكن من سهولة الوصول, و يعزز إستخدام أنماط نقل صديقة للبيئة, لذا يُعدّ من الافضل توقيع المدينة الايكولوجية على المحور الرئيس للبنية التحتية القائمة لوسائل النقل العام أو بالقرب من ما يمكن تطويرهُ منها مستقبلياً بصورة سهلةً و إقتصادية.
- التقليل من إستخدام الاراضي الجديدة عن طريق إعتماد نموذج المدينة المتضامة (Compact City), و إختيار أفضل المناطق لتوقيع الانشطة الصناعية والتنمية المستقبلية للمدينة, كما يجب النظر فيما أذا كان الموقع مناسب لتنمية عالية الكثافة أم لا على أن يتم ذلك في ضوء دراسة كثافات المناطق الحضرية المجاورة لهُ.

2-4 مقوم البنى الارتكازية الخضراء و أسسهُ التخطيطية والتصميمية :

تُعرف البنى الارتكازية الخضراء على أنّها " شبكة مخططة استراتيجياً من المناطق الطبيعية وشبه الطبيعية عالية الجودة فضلاً عن العناصر البيئية الاخرى, و التي يتم تصميمها و إداراتها لتُقدم مجموعة واسعة من خدمات الانظمة الايكولوجية وحماية التنوع الحيوي في كلا المنطقتين الريفية والحضرية". و يعبر هذا التعريف عن هيكل مكاني يُصمم لتقديم خدمات الطبيعة لمناطق التجمع الحضري, فهي تهدف الى تعزيز القدرة الطبيعية للموقع على تقديم سلع و خدمات الانظمة الايكولوجية الطبيعية (European Union, 2013,p7,p1) . و يمكن تلخيص أهم الاسس التخطيطية و التصميمية لهذا المقوم بما يأتي :

أ) حماية عناصر البنى الارتكازية الخضراء الموجودة في الموقع و محيطهِ و تقوية أدائِها : يعد من أهم الاجراءات التي يشتمل عليها هذا الاساس التخطيطي هو مكافحة فقدان التنوع البيولوجي في موقع إنشاء المدينة الايكولوجية, و تقوية الاداء الوظيفي للانظمة الايكولوجية ضمنها, و زيادة مرونة هذهِ الانظمة عن طريق تحسين التواصل المكاني و الوظيفي لها , و تعزيز التخطيط المكاني المتكامل لها, فضلاً عن ضرورة إعادة النظر في طريقة تخطيط البنى الارتكازية التحتية القائمة أو المراد إنشاءها مستقبلاً (في مجال إدارة المياه و النقل والتنمية الحضرية مثلاً) وذلك من أجل التخفيف من أثار الحواجز الفاصلة التي تسبب بها عناصر تلك البنى (Dudau M. ,2011,p5,p1).

ب) التخطيط المكاني : ينطوي الشروع في تخطيط و تصميم عناصر البنى الارتكازية الخضراء المضافة الى المدينة الايكولوجية على دراسة ثلاثة عناصر رئيسية للموقع المقترح لها وهي السياق والهوية والاتصال حيث تعد البنى الارتكازية الخضراء وسيلة للنظر في هذهِ العناصر الثلاث و تقويتها (The Scottish Governmen ,2011,p8,p1). **يعكس** مفهوم التخطيط المكاني للبنى الارتكازية الخضراء فهماً واضحاً لماهية هذهِ العناصر الثلاث و لقيمتها الوظيفية الايكولوجية والاجتماعية لذا فهو يعتمد في منهاجية عملهِ على التخطيط والتصميم بموجب ما يتناسب مع سياق الموقع و ما يحافظ على هويتهُ ويعزز الانتقال والتواصل للمشاة والموائل الطبيعية ضمنهُ.

ج) التواصلية : يتمثل هذا العامل في تخطيط المكونات الخضراء والزرقاء للمدينة بهيئة شبكة متواصلة من العناصر الطبيعية مع تجنب حدوث الانقطاع بين هذهِ العناصرالى أقصى قدر ممكن. تؤكد أغلب الدراسات الحضرية في مجال الطرح النظري والتنمية العملية والادارية للشبكات الخضراء على فكرة أن الطبيعة كانت متواصلة قبل تدخل الانسان فيها و إنّ زيادة نسبة التواصل في تصميم عناصر الشبكات الخضراء سيكون أمراً جيداً ومفيداً (Barker G.,1997,p5,p3).

د) توفير مساحات كافية لمعالجة إنبعاثات الكاربون و موازنتها طبيعياً : يهتم هذا العامل بتوفير المساحات الخضراء اللازمة لإستيعاب ما تنتجهُ الحياة الحضرية في المدينة الايكولوجية من غاز ثنائي أوكسيد الكاربون, حيث يمكن تحقيق هذا العامل عن طريق حساب الكمية الكلية لإنبعاثات غاز ثنائي أوكسيد الكاربون ومن ثم معادلتها بقدرة النباتات على التنحية الطبيعية له (Berthold J. & Wetterwik M.H. ,2013,P49,P2).

هـ) سهولة الوصول : من أهم شروط الحصول على بنى أرتكازية خضراء ناجحة بيئياً و إجتماعياً هو تخطيطها وتصميميها بطريقة تجعل منها جزءً أساسياً في الحياة اليومية للمدينة وذلك عن طريق تسهيل الوصول اليها دون تعب أو جهد وجعلها قريبة من السكان وفي متناول أيديهم (Barker G.,1997,p5,p3).

3-4 مقوم البيئة المبنية و أسسهُ التخطيطية والتصميمية :

أنّ من أهم ما يتميز بهِ مخطط البيئة المبنية في المدينة الايكولوجية الصديقة للبيئة هو التأكيد على مبدأ (التضام - Compactness) في طريقة تخطيط وتصميم مفردات تلك البيئة كافة. يحدد مفهوم (التضام أو التراص) القُرب بين الإستخدامات والوظائف الحضرية على أن ينسجم مع إنموذج النقل المستخدم والفضاءات العامة وجميع الاراضي ذات الصلة (Rueda S.,2012,p14,p1). و يمكن تلخيص أهم الاسس التخطيطية و التصميمية لهذا المقوم بما يأتي :

أ) الارض مختلطة الاستخدام : يسمح إعتماد عامل التنطيق الارضي مختلط الاستخدامات (mixed land use) بإيجاد حالة من التوافق في تخطيطإستخدامات الارض في المناطق الحضرية, إذ يسعى هذا العامل الى توقيع غالبية الفعاليات السكنية والتجارية والترفيهية قرب بعضها البعض, مما سيؤدي بدورهِ الى تقليل مسافة التنقل اليومي بينها (Parker T.,1994,p11,p1). هنالك معايير معينة تتعلق بحجم المناطق مختلطة الاستخدامات وبنسبة الإختلاط ضمنها,إذ يُوصى بأنّ لا تتجاوز مساحة المنطقة المختلطة الواحدة عن (10هكتار) بأبعاد (300 * 300 متر) أو (500 * 200متر) أو أية أبعاد تحقق المساحة نفسها, كما يجب أن تشتمل هذهِ المنطقة على المزج بين أماكن العيش والعمل بصورة منسجمة ومتكاملة, حيث يجب أن تطبق قوانين المزج الجيد على مستوى البناية الواحدة و قوانين المزج الواسع للإستخدام المختلط على مستوى الحي الحضري المفرد او المدينة ككل. أما فيما يتعلق بنسبة الفعاليات, فإنّ قيمة الإختلاط الموصى بها للمناطق الارضية من الاحياء الحضرية تتراوح ما بين (30%) كحد أدنى الى (80 %) كحد أعلى للفعالية السكنية, وبين (20%) كحد أدنى و (70%) كحد أعلى لأماكن العمل (Coplák J. & Rakšányi P., 2003,p46,p2)*.

ب) الكثافة العالية المؤهلة (المناسبة) : هنالك مدى عام للكثافة الحضرية في المدينة الايكولوجية حيث أن تعين الإختلافات ضمن هذا المدى يعتمد على الاوضاع المحلية لعمليات التنمية, و يتمثل هذا المدى بما يأتي Gaffron P. & et al ,2008,p25,p4) :

- إجمالي مساحة طوابق المبنى / مساحة القطعة التي بنيت عليها = (0.8 الى 0.3)

* المعايير المثبتة في النصوص أعلاه هي معايير عامة لأنشاء بيئة مبنية ايكولوجية صديقة للبيئة فهي ليست خاصة بدولة أو أقليم معين أو منظمة معينة و قد أتفق عليها عدد مختلف من الباحثين في مجال الانشاء الحضري الايكولوجي، أذ يُلاحظ تواجد نسبة من المرونة فيها تحددها الشروط و المواصفات المحلية لموقع المدينة الايكولوجية الصديقة للبيئة.

- نسبة تغطية المبنى / مساحة القطعة = (0.35 الى 0.7), و تتسم المخططات الناتجة عموماً بأنّها منخفضة الى متوسطة الارتفاع (3-6 طابق) مع كثافات عالية (100الى250 ساكن/هكتار), علماً أن أعداد باقي المستخدمين من عاملين و طلاب و زوار تحسب بمعزل عن هذهِ الكثافات كقيمٍ مضافة.

ج) التأكيد على الفضاءات العامة في المدينة (البنى الارتكازية الحضرية) : يمثل الفضاء العام العنصر الهيكلي الاكثر حضوراً في إنموذج المدينة الايكولوجية, فهو فضاء التعايش والتشكيل وتوفير شبكات المرافق العامة و المناطق الخضراء و أماكن الاقامة والمحاور الرئيسة للحياة الاجتماعية والعلاقات, بذلك فإنّ نوعية الفضاء العام في المدينة الايكولوجية لا تعتمد على مفهوم (التضام) فقط وأنما على مفهوم (الاستقرار) الذي يوفره ذلك الفضاء كذلك (S.,2012,p14 Rueda).

د) تأهيل الابنيـــــــة المستدامة في المدينة الايكولوجية : يشتمل تأهيل الابنية المستدامة في المدينة الايكولوجية على تفعيل عدد من الستراتيجيات التصميمية ومنها (لينور آل رفو , 2008, ص423,ج2):

- ضرورة إنسجام و تكامل الابنية مع البيئة الطبيعية و الحضرية للموقع.
- الإستفادة من التنوع في أشكال الطبيعة الناتج عن التنوع في الطوبوغرافية الارضية عند التعامل مع الموقع .
- تصميم الابنية بطريقة تستثمر ما يتوفر في الموقع من مصادر متجددة؟
- توظيف التكنولوجيا الحديثة قليلة إستهلاك الطاقة في كافة مراحل قيام هذهِ الابنية.
- تحقيق الإستفادة القصوى من خصائص النظام الايكولوجي للموقع دون الاضرار بتلك الخصائص " أي جعل التصميم نابع من البيئة دون تدمير للنظام الايكولوجي الموضعي ".
- التحكم و معالجة النفايات الناتجة عن المبنى طوال مراحل وجودهُ.

4-4 مقوم النقل و أسسهُ التخطيطية والتصميمية :

يتضمن تحقيق مفهوم النقل المستدام الصديق للبيئة تحقيق نهج رئيس ثلاثي الابعاد يتمثل بـ(تجنب) الرحلات التنقلية غير الضرورية و التقليل من أطوال الرحلات اليومية التي يقوم بها الساكنين, و بـ(أزاحة) الركاب نحو إستخدام وسائط نقل أكثر توافقاً مع البيئة, و بـ(تحسين) ممارسات تكنولوجيا النقل (Pardo C.F., 2010,p13,p3)(ADB,2009,p39). ينطوي تحت ظل هذا النهج العام عدد من الاسس التخطيطية و التصميمية و منها ما يأتي :

أ) إنشاء أحياء متضامة موجهة لحركة المشاة : يؤدي إعتماد مبدأ التضام (الارض مختلطة الاستخدام و الكثافة العالية المؤهلة) في عمليات تخطيط و تصميم أحياء المدينة الايكولوجية الى جمع غالبية المقاصد اليومية السكانية معاً مما سيُقليل الحاجة الى النقل, ولاسيما الآلي منه, والى الترويج للقيام بغالبية التنقلات اليومية مشياً على الاقدام أو ركوباً على الدراجات الهوائية (GIZ,2004,p2,p4)*.

ب) التوقيع المناسب للمدارس والخدمات العامة الاخرى : يؤكد هذاالعامل التخطيطي على ضرورة توقيع الخدمات الاساسية العامة ضمن مسافات تسمح بأسهل وصول ممكن وعن طريق التنقل سيراً على الاقدام, حيث يفضل أن تفصل المسكن عن المرافق العامة ما لا يزيد عن (500م), وعن مرافق رعاية الاطفال والمدارس ما لا يزيد عن (300 م), كما

* GIZ هو عنوان مختصر لمؤسسة الاتحادية الالمانية للتعاون الدولي (Deutsche Gesellschaft für Internationale Zusammenarbeit), وهي مؤسسة دولية مملوكة من قِبَلِ الحكومة الاتحادية الألمانية تعمل في العديد من المجالات في أكثر من (130) بلد مشتركةً مع عناصر بارزة في القطاعين العام والخاص لهذهِ البلدان (http://en.wikipedia.org).

يجب أن تراعى وبشدة المسافة التي يقطعها الفرد وصولاً الى محطات النقل العام و وسائطه المختلفة** (Skala F. ,2010,p8).

ج) تصميم خالي من حركة السيارت الخاصة : تعتمد فكرة إنشاء الاحياء الخالية من حركة السيارات الخاصة على منع السيارات تخطيطياً من الدخول الى داخل قطاعات المدينة الايكولوجية, حيث تقتصر حركتها على الشوارع الرئيسة فيها فقط منتهيةً عند أطراف هذهِ القطاعات في نقاطٍ معينة تُمثل مواقفاً لهذهِ السيارات (Gaffron P & et al ,2008, p30) .

د) التأكيد على ممرات المشاة و الدراجات الهوائية : هنالك مجموعة من العوامل المحددة التي يمكن أن تؤثر في دور وفعالية ممرات المشاة و الدراجات الهوائية, ومنها عوامل الجذب و أنماط أستخدام الارض و مسافات الرحلات و الاوضاع المناخية و التركيبة السكانية و الاقتصادية والمواقف المجتمعية (Schwartz W.L. & et al ,1999,p5).

هـ) تحسين أدائية نظام النقل العام : يجب أن تكون خدمات النقل العام سهلة الوصول مكانياً (مسافة قصيرة لمحطات النقل), و زمانياً (وقت انتظار قليل). يعتمد عادةً تحقيق مفهوم (سهولة الوصول) على مجموعتين من المعايير ترتبط الاولى بالمسافات التي يقطعها الفرد وصولاً الى محطات النقل العام, في حين ترتبط الثانية بعدد الوجهات التي يمكن الوصول اليها عن طريق وسائل النقل (U.S. EPA , 2011,p11,p2)***.

5-4 مقوم الطاقة و أسسهُ التخطيطية والتصميمية :

تعتمد ستراتيجات المدينة الايكولوجية في مجال تخطيط و تصميم مقوم الطاقة و تدفق المواد فيها على تحقيق مبدأ (التأزر) في تدفقات الموارد بين أنظمة البنى التحتية للمدينة من جهة وبين أنظمة البنى التحتية و البيئة المبنية من جهة أخرى. و يمكن تحقيق ذلك من خلال سلسلة من الاسس التخطيطية و التصميمية ومنها:

أ) التصميم المتضام للابنية مع ضمان توفير المواصفات التشميسية القياسية لها: يؤكد هذا العامل – الذي يُعد أحد عوامل تحقيق مفهوم النقل المستدام الصديق للبيئة- على إعتماد التنمية الحضرية المتضامة (مبانٍ متُعدّدة الطوابق أو صفوف من المنازل المتلاصقة) كأساس في عمليات التنمية الحضرية في المدينة الايكولوجية (Fuerst F. & Wegener M.,2013,p2,p5).
تنطوي معايير تصميم الاحياء المتضامة الكفوءة في مجال إستخدام الطاقة على ضرورة مراعاة طريقة تسقيط المباني ضمنها؛ وذلك لتحسين التعرض الشمسي لهذهِ المباني, و المشاركة في خلق ستراتيجيات تصميم منفعلة جيدة (RMA,2002,p17,p2).

ب) إعتماد ستراتيجيات التصميم المنفعل في تصميم المبنى المفرد: تسعى ستراتيجيات و عناصر التصميم المنفعل (passive design) الى تحقيق الراحة المرئية و الحرارية للفرد في داخل المبنى؛ وذلك بالإعتماد على مصادر الطاقة الطبيعية و مصارفها, مثل الاشعاع الشمسي و الهواء الخارجي و الاسطح الرطبة و الغطاء النباتي. يؤدي تفعيل هذهِ الستراتيجيات الى إحداث تقليل واضح و مهم في معدلات إستهلاك الطاقة اللازمة لتوفير الراحة المناخية داخل المبنى عن طريق تقليل الإعتماد على الطرق التقليدية المتمثلة بتشغيل مكيفات الهواء الميكانيكية و الاضاءة الصناعية للمبنى.

** المعايير المثبتة في النصوص أعلاه هي معايير عامة لأنشاء بيئة مبنية صديقة للبيئة فهي ليست خاصة بدولة أو أقليم معين أو منظم معينة و قد أتفق عليها عدد مختلف من الباحثين في مجال الانشاء الحضري الايكولوجي، أذ يُلاحظ تواجد نسبة من المرونة فيها تحددها الشروط و المواصفات المحلية لموقع المدينة الايكولوجية الصديقة للبيئة.

*** (U.S. EPA) هي إشارة مختصرة لوكالة الحماية البيئية الامريكية (U.S. Environmental Protection Agency) .

ج) إعتماد ستراتيجيات التصميم الفعال في سد الطلب على الطاقة المطلوبة : و ذلك من خلال زيادة إستثمار المصادر المحلية المتجددة في عمليات توليد الطاقة و سد الطلب المحلي عليها (Anastasiadis P. & Metaxas G. ,2013,p396,p5) .

د) الادارة المستدامة لمصادر المياه : تعتمد برامج إدارة المياه في المدينة الايكولوجية على ضرورة تحويل الصيغة العامة لادارة المياه من صفتها الخطية (الحد الادنى لإعادة الإستخدام) الى صفةً جديدة مغلقة ودائرية (الحد الاعلى لإعادة الإستخدام والتدوير) (Novotny V. & Novotny E.V. ,2009,p1,p2).

هـ) الانتاج المصفر للنفايات : تعتمد المدينة الايكولوجية في تحقيقها لنظام إدارة نفايات جيد ومستدام طبيعياً على أجرائيين الاول هو تقليل الإنتاج الاولي للنفايات , و الثاني هو التعامل مع النفايات التي لابد من تولدها على أنها جزءً مهماً ومكملاً لإدارة الموارد الحضرية المتجددة في المدينة (Mroueh U.M. ,2007, pp3-4).

5- المدينة الايكولوجية في التجارب العالمية:

يتضمن هذا الجزء من البحث دراسة لعدد من التجارب العالمية المنتخبة في مجال إنشاء المدينة الايكولوجية وفق منظور وصفي تحليلي مقارن؛ وذلك بغية التحقق من إمكانات تطبيق ما توصل اليهِ الطرح النظري في الفقرات السابقة على ارض الواقع.

التجربة الاولى : التجربة السويدية / منطقة هاماربي سجوستد (Hammarby Sjöstad) / عام 2010

تقع هذه المنطقة ضمن السلطة الإدارية لبلدية العاصمة السويدية (ستوكهولم) على الضفاف المقابلة لبحيرة (Hammarby Sjö) في الضواحي الشمالية لمنطقة (Söndermalm) (شكل 4). يبلغ أجمالي المساحة الكلية للمنطقة نحو (160هكتار), هي مخصصة لتحتوي على (11 الف وحدة سكنية) و قادرة على اسكان (24الف) شخص, وبكثافة أسكانية إجمالية تصل الى (150 شخص/هكتار) (http://international.stockholm.se). يشكل مقوم النقل العنصر الاكثر تأثيراً في تخطيط هذهِ المنطقة حيث تشكل طرقهُ الرئيسة الجادة الأساسية التي تخترق المدينة من أقصاها الى أقصاها (شكل 5). تنتظم حول هذهِ الجادة غالبية البيئة المبنية للمنطقة على شكل عدد من الاحياء مختلفة المساحات (شكل6) (Goel S.,2013,12). توجد البيئة المبنية لهذهِ المنطقة على شبكة من العناصر الخضراء ؛ وذلك لغرض تحقيق الموازنة الطبيعية مع كثافة المشهد الحضري المتبعة في المنطقة. و قد كان المعيار الاساس لهذهِ الشبكة هو توفير (25م^2) من المساحات الخضراء العامة لكل وحدة سكنية, أي ما يقترب من (300 الف م^2) لعموم المنطقة (شكل 7-8) (Foletta N.) (& Filed S. , 2011 ,p38.كما يسعى تخطيط و تصميم مقوم الطاقة و تدفق المواد ضمن منطقة (Hammarby Sjöstad) الى تحقيق نهج شمولي في توفير خدمات البنى الارتكازية عن طريق دمج عدد من الانظمة المنفصلة في إنموذج واحد يتأخذ من مخرجات نظام معين مدخلاتٍ لنظام آخر (نموذج الدورة الايكولوجية - Eco cycle model)(شكل9), و قد أدى إعتماد هذا الإنموذج الى إنتاج حلول بيئية جديدة و متكاملة في مجال إدارة تدفقات الطاقة والنفايات و المياه و مياه الصرف الصحي ضمن هذهِ المنطقة (Strandell J. & Li D. ,2012,p12).

التجربة الثانية : التجربة الفنلندية / حي (Eco-Viikki) / عام 2004

يقع حي (Eco-Viikki) ضمن حدود مدينة (Viikki) على مقربة من مركز العاصمة الفنلندية هلسينكي (Helsinki) بمسافة تصل لنحو (8كم) (Schulz C.,2006,p12 ,p1). خُصصت هذهِ المنطقة البالغ مساحتها (23هكتاراً),

والكافية لاسكان ما يقترب من (1700 شخص) لتكون بمثابة حقل إختباري لتطبيق الرؤى والحلول الايكولوجية الممكن تنفيذها على مستوى الحي السكني المفرد (شكل10) (Hakaste H.& et al ,2005,p8,p5). شكلَ مقوم البنى الارتكازية الخضراء المضافة للموقع العامل الاكثر تأثيراً في بنية هذا الحي الايكولوجي حيث تمتد الاصابع الاخضراء على هيئة ثلاث متنزهات طولية لتكون الهيكل الاساس لبنية الحي . تنتظم حول هذا الهيكل جميع الكتل المبنية, ليمتلك بذلك كل موقع أو مبنى سكني ضمن هذا الحي إرتباطاً مباشراً مع الطبيعة الخضراء المحيطة بهِ (شكل11) (HCPD,2010,p14,p1). تسيطر الفعالية السكنية على مخطط إستعمالات الارض في هذهِ الكتل المبنية مع تخصيص جزء بسيط منهُ لتوفير ما يحتاجهُ السكان من خدمات يومية,مثل مركزين للرعاية النهارية ومدرسة و محال تجارية (شكل12). كان من أهم ما يميز مقوم البيئة المبنية في هذا الحي هو تأهيل الابنية المستدامة و ذلك عن طريق توجيه غالبية الكتل البنائية ضمن هذا الحي الايكولوجي باتجاه (الجنوب) من أجل زيادة التعرض الشمسي, و زيادة الأستفادة من الطاقة الشمسية (P. Droege ,2012,p147,p1). كما راعت معايير تصميم الابنية في حي (Eco-Viikki) خمس جوانب رئيسة و هي التلوث و إستهلاك الموارد الطبيعية و صحة الابنية و إستدامة التنوع البيولوجي و إنتاج الغذاء (شكل13) (Ojala K.,2010,p1,p1). أعتمد مخطط مقوم النقل في هذهِ التجربة على إستخدام السيارات الخاصة. ولكن بصفة محدودة وغير مهيمنة على تخطيط الحي, حيث لا تنتشر شبكة طرق السيارات ضمن الحي بأكملهِ وإنّما تقتصر على طريق محوري يقسم المنطقة الى نصفين غير متساويين ليرتبط مع الطريق الرئيس لمنطقة (Latokartano) (شكل14) (حسب مراجعة خرائط الـ Google Earth).

التجربة الثالثة : التجربة الاماراتية / مدينة مصدر / مازالت قيد الانشاء(2015م)

تقع مدينة مصدر على بعد (11 ميل) الى الجنوب الشرقي من إمارة أبو ظبي في دولة الإمارات العربية المتحدة (Stilwell B. & Lindabury S. ,2008,p2,p1). تبلغ مساحة مدينة مصدر نحو (590 هكتار) أي ما يقترب من (6كم مربع) مخصصة لاغراض سكنية و تجارية وتعليمية وصناعية خفيفية مختلفة (Al mubadala Company,2009,p4,p2). أنطلق تخطيط المخطط العام لمدينة مصدر من دراسة مفصلة و دقيقة للمستوطنات العربية القديمة وكيف إستطاعت المجتمعات أنذاك بناء مستوطنات صالحة للعيش في أقاليم شديدة الحرارة (Ouroussoff N., 2010). جاء المخطط العام لهذهِ المدينة على هيئة تشكيلين مربعين حضريين أحدهما أكبر من الاخر محاطان بحقول المناظر الطبيعية المفتوحة, وبمرافق توليد الطاقة المتجددة. و قد ظهر تأثير الدراسة المفصلة للمستوطنات العربية القديمة و لعناصر التصميم المنفعل ضمنها في توجيه هذين التشكيلين المربعين على محور جنوبي شرقي – شمال غربي (38 درجة عكس إتجاه عقارب الساعة من محور الشمال)؛ وذلك بغية توفير الظلال لكافة الطرق فيهما طوال اليوم (شكل16) (Kubis M. ,2011,p8) (Foster N. ,2011,p3). تميز مخطط مدينة مصدر بشوارع ضيقة تتراوح بين (14- 8.5 متر) ماعدا الشارع المركزي الذي يبلغ عرضهُ (25متر) (Masdar City, 2010,p4,p2). كان السبب الرئيس وراء إختيار هذهِ الابعاد هو توفير الظل المناسب للابنية, والسماح للاشعة الشمسية غير المباشرة بالوصول الى فضاءاتها الداخلية كافة. ترتفع المدينة بأكملها الى مستوى (23 قدم, أي نحو 7متر) فوق مستوى سطح الارض؛ وذلك لتوفير الفضاء المناسب للعديد من البنى الارتكازية الحضرية التي سيتم إنشاءها في مستوى السرداب (شكل17) (Snyder L.,2009,p5,p2). لقد إعتمد مخطط البنى الارتكازية الخضراء لمدينة مصدر على تطبيق فكرة (الاصابع الخضراء) التي تخترق التشكيلين المربعين للبيئة المبنية من أقصاها الى أقصاها, والحزام الاخضر الذي يحيط بهما (شكل 18) (Al mubadala Company ,2009,p8,p1). تمتاز مدينة مصدر بشوارعها الضيقة المظللة المريحة حرارياً, و المخصص غالبيتها لحركة المشاة, حيث صممُ مقوم النقل ضمنها بصورة لا تتعارض مع

حركة المشاة, و لا تتسبب في إنبعاث أي قدر كان من الكاربون, فقد سعى مخططوا هذا المقوم الى إيجاد نظام نقل صديق للبيئة متنوع و شامل لحركة السكان والعاملين ضمن المدينة و خارجه (شكل19) (ADFEC,2011,p50).

الاستنتـــاجات

يمكن تلخيص اهم ما توصل اليه البحث في مجال المدن الايكولوجية الصديقة للبيئة بعدد من الإستنتاجات, التي يمكن إجمالها بالآتي:

1- تعتمد الفكرة العامة لإنشاء المدن الايكولوجية الصديقة للبيئة على الإدراك الشمولي و الحقيقي لقيم الآنظمة و الاصناف في الطبيعة, و على الابتعاد عن عدّها مجرد خدمات مجانية مخصصة لراحة الانسان و رفاهيتهِ. ينطوي هذا الادراك على تقييم حقيقي للوحدات و الاجزاء و الانظمة في الطبيعة لـ(ذاتها) بغض النظر عن قيمتها بالنسبة للانسان, مما يستوجب ضرورة الحفاظ عليها لأهميتها بالنسبة للكون و لبعضها البعض, و ليس لأهميتها بالنسبة للانسان الذي يُعدّ العنصر الاكثر استهلاكاً لها.

2- تسعى مفاهيم إنشاء المدينة الايكولوجية الى تأمين مناطق وجود حضري تحافظ على مستقبل الانظمة و الاصناف في الطبيعة عن طريق العمل بنفس آلية تلك الانظمة, لتكون المدن عبارة عن أنظمة أيكولوجية حضرية تتعاون مع الانظمة الايكولوجية الطبيعية تحت سقف القوانين و الخصائص التشغيلية نفسها بغية تحقيق الاهداف ذاتها بما يضمن لكلاهما الحق في الوجود والاستمرار دون أن يُضر أيٌ منهما بالاخر.

3- يؤكد طرح المدينة الايكولوجية الصديقة للبيئة على أهمية تقليل كل من المدخلات والمخرجات الحضرية؛ لآن لكل منهما آثاراً سلبية في البيئة؛ ولأن تقليل إستخدام المدخلات و إنتاج المخرجات سيضمن حق الحياة والاستمرار للانسان و لمكونات الطبيعة الحية وغير الحية على السواء. تهدف المدينة الايكولوجية الى تحقيق ذلك الترشيد عن طريق تغيير طريقة عمل الديناميكات الحضرية, و إعتماد مبادىء التأزر و غلق الدوائر كأساس في تصميم مسارات تدفق الطاقة و الموارد ضمنها.

4- لا تفرض المفاهيم التخطيطية والتصميمية التي جاءت بها النظرية الايكولوجية في مجال إنشاء المدن الصديقة للبيئة إنموذجاً تخطيطياً مسبقاً - كما حدث في نظريات إنشاء المدن المستدامة التي ظهرت في منتصف القرن العشرين – بل العكس تماماً, فهي تؤكد على ضرورة الإلتزام بالخصائص الايكولوجية الموقعية في إنتاج إنموذج تخطيطي أيكولوجي منسجم مع موقعهِ من جهة, و مع تحقيق أهداف المدينة الايكولوجية من جهة أخرى .

5- إرتباط قرارات توقيع مناطق التنمية الحضرية و مناطق الحفاظ والتأهيل و الاستعادة للأنظمة الطبيعية مع الخصوصية الطبيعية لموقع المدينة الايكولوجية معتمدة على دراسة موسعة و مفصلة لصفات تلك الخصوصية و قيمتها الذاتية و قيمتها للبشرية فضلاً عن دراسة مدى حساسيتها للتدخلات البشرية ضمنها و كيفية منع هذهِ التدخلات أو التقليل من أضرارها .

6- إنطلاق القرارات التخطيطية العامة, ولاسيما تلك المرتبطة بشكل المخطط الأساس للمدينة الايكولوجية من الخصوصية المناخية و الثقافية لموقعها؛ و ذلك لتحقيق بيئة مريحة مناخية من جهة, و مألوفة اجتماعياً و ثقافياً من جهة أخرى, بما يخلق مدن صديقة للساكن و قريبة من معتقداته و مفاهيمهِ.

7- تشكيل مقوم البنى الارتكازية الخضراء للعنصر الاكثر تأثيراً في التكوين الداخلي للمخطط الأساس للمدينة الايكولوجية, وما يترتب عنهُ من تكوين للقطاعات البنائية المختلفة . أهم ما يمكن ملاحظتهُ في غالبية التجارب العالمية في مجال إنشاء هذهِ المدينة هو وجود شبكة متواصلة من العناصر الخضراء و الزرقاء مختلفة الاحجام منتشرة في عموم مخطط المدينة الايكولوجية مكونةً قاعدةً طبيعية تجلس عليها كتل الانسان الحضرية لتوزان كفة التدخل البشري في الطبيعة و لتقلل و تستوعب تأثيراته.

8- لا ينفصل إنموذج تخطيط المدينة الايكولوجية عن ما يحتويهِ موقعها في الاساس من مسطحات وعناصر مائية, بل يتناغم معها متوجهاً في كتلهِ نحوها و مستغلاً إياها للفعاليات العامة, و لخدمات النقل المائي. ينطوي مخطط المدينة الايكولوجية غالباً على إستثمار هذهِ المسطحات والعناصر والسعي لزيادة أدائها و تغذيتها المستمرة؛ وذلك لزيادة دور الطبيعة في تقليل آثر الوجود الحضري ضمنها, و المشاركة في التخفيف من ظاهرة التغيير المناخي و المشكلات الناتجة عنها.

9- تخطيط وتصميم البيئة المبنية ضمن المدينة الايكولوجية بهيئة عدد من الاحياء محدود الاحجام (لتشجيع الحركة سيراً على الاقدام), و مختلطة الإستخدام (لخلق مراكز حضرية حيوية طيلة اليوم), و متوسطة الارتفاع (لتقليل الضغط على البنى التحتية الرمادية) متوزعة في الغالب حول طريق محوري تمر ضمنهُ وسائل النقل العام المختلفة .

10- يعتمد تخطيط مقوم النقل في غالبية التجارب العالمية المتفق عليها كمحاولات رائدة في إنشاء المدينة الايكولوجية على تقليل الحاجة للنقل بالدرجة الاولى؛ و ذلك عن طريق توقيع الفعاليات قرب بعضها البعض, و على إيجاد وسائل نقل أقل تلوثاً للبيئة بالدرجة الثانية؛ و ذلك عن طريق التشجيع على التنقل غير الآلي, فضلاً عن زيادة أدائية وسائل النقل العام مقابل تقليل مغريات الركون الى السيارات الخاصة للتنقل ضمن أحياء هذهِ المدينة .

11- ترتبط قرارات و نسبة الإعتماد على التنقل غير الآلي (السير على الاقدام أو ركوب الدراجات الهوائية) مع الخصوصية المناخية والثقافية للمجتمع الموجود ضمن حدود المدينة الايكولوجية . تقل حوافز الركون الى مثل هكذا نوع من التنقل في المناطق ذات الشتاء البارد جداً أو الصيف الحار جداً, كما تشارك العقائد والمفاهيم والديانات في تحديد هذهِ النسبة, ولا سيما في المجتمعات المحافظة التي قد تستثقل ركوب المرأة على الدراجات الهوائية في الشارع. فرضت هذهِ الخصوصية المناخية والعقائدية تغيراً واضحاً في تخطيط مقوم النقل ضمن مدينة مصدر, حيث المناخ الصحراوي الحار و الطبيعة المجتمعية المحافظة, مما أدى الى ضرورة و حتمية الاعتماد على وسائل نقل آلية, و التي جاءت بصيغ سيارات كهربائية تعتمد على الطاقة المتجددة. تضمن هذهِ المعالجات تقليلاً واضحاً في الآثار البيئية المترتبة عن النقل ضمن المدينة, ألاّ إنّ تكون أكثرُ كلفةً من الناحية الاقتصادية.

12- تفعيل دور مصادر الطاقة المتجددة في سد الطلب على الطاقة الحضرية, مما أدى الى ظهور مفردة جديدة ضمن المخطط العام للمدينة الايكولوجية و الرؤية النهائية لها, وهي محطات إنتاج الطاقة و منظوماتها الفرعية المنتشرة ضمن فضاءات هذهِ المدينة و فوق سطوح أبنيتها .

13- إنطلاق قرارات تصميم الابنية المنفردة من نفس الاهداف و الرؤى العامة التي تسعى اليها المدينة الايكولوجية, و المتمثلة بتقليل الطلب على الاراضي و الطاقة والموارد؛ وذلك عن طريق تأهيل الابنية المستدامة, و توظيف ستراتيجات التصميم المنفعل ضمنها .

14- عدّ المخرجات (النفايات و مياه الصرف الصحي) مصدراً للطاقة التي تتجدد باستمرار وجود الانسان في المدن ضمن الطبيعة, و النظر اليها بوصفها مورداً للطاقة أكثر من كونها مواد ضارة يجب التخلص منها.

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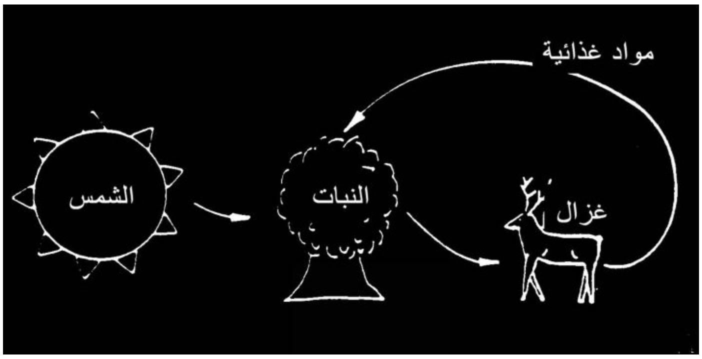
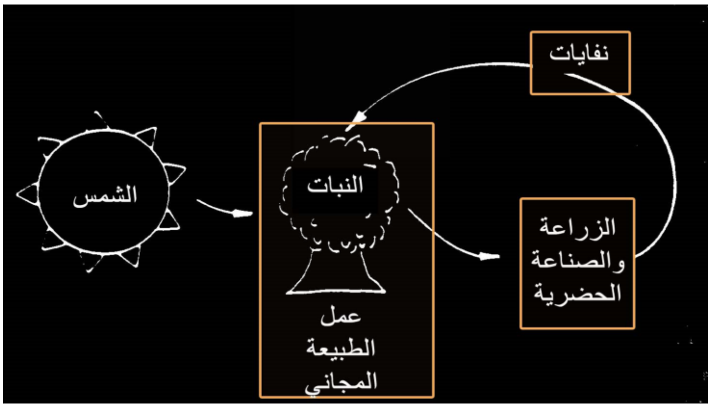
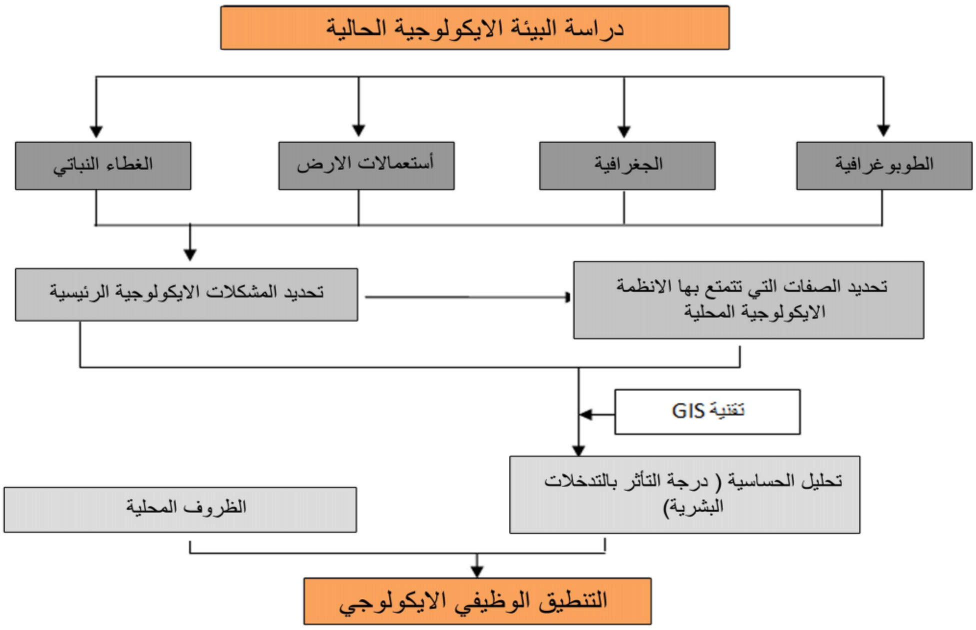


شكل (1) إنموذج (Odem) يقدم توضيحاً مبسطاً للعلاقات الاساسية والارتباطات في النظام الايكولوجي . يتميز هذا الإنموذج بالبساطة والوضوح, إذ يشير الى الاستدامة عن طريق التدوير والخزن و الارتباط مع المصادر المتجددة (Williams D.E., 2007,p3,) .

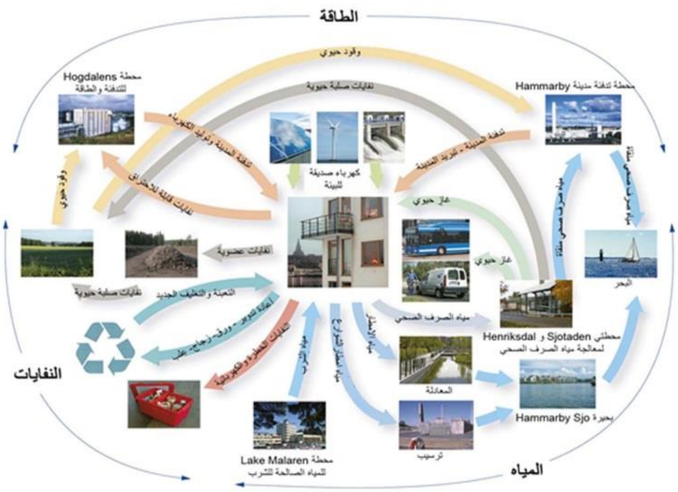


شكل (2) أستخدام إنموذج (Odem) كإنموذج لإنشاء المدن الايكولوجية, إذ تمثل الفعاليات الحضرية الكائنات المستهلكة, في حين تشكل النفايات الناتجة عن هذهِ الفعاليات المواد الغذائية التي يمكن عن طريق اعادة تدويرها أن تكون مصدراً للطاقة المتجددة (Williams D.E., 2007,p3) .



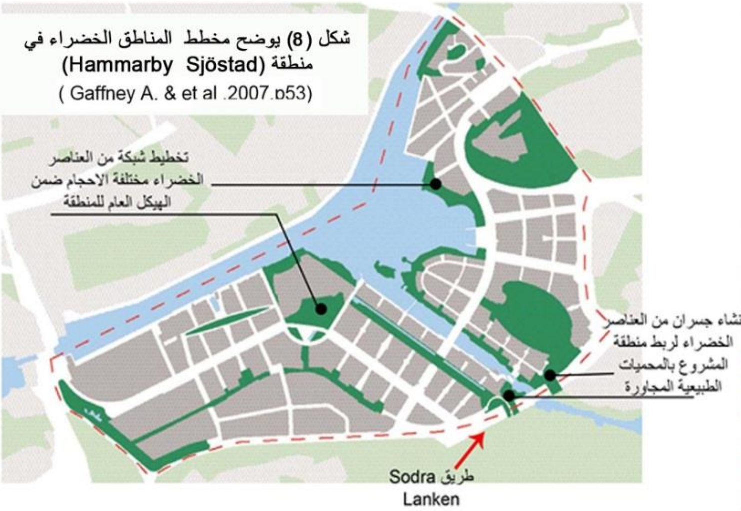
شكل(3) منهجية التنطيق الوظيفي الايكولوجي (Tain G. & Zhang L.,2013,p108)

شكل (4) يوضح موقع منطقة (Hammarby Sjöstad) من دولة السويد, ومن العاصمة السويدية
http://www.skyscrapercity.com

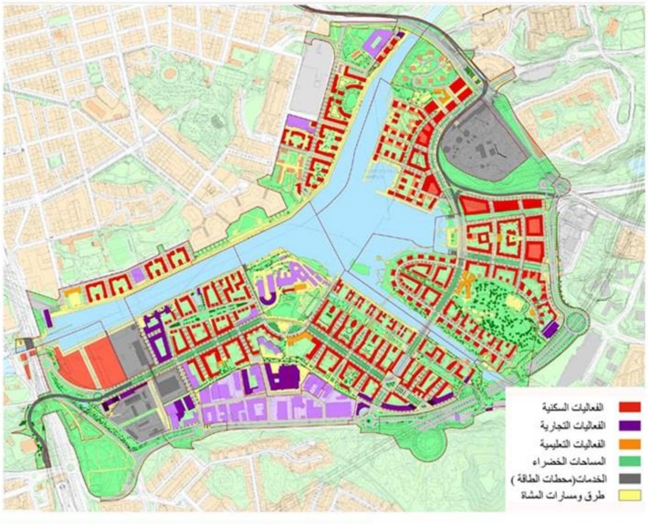


شكل (9) يوضح إنموذج الدورة الايكولوجية – Eco cycle و الذي يؤكد على تكامل تدفقات الطاقة ضمن البيئة المبنية, وعلى تحقيق أكبر إستفادة ممكنة من الموارد المستهلكة (Fortum, Stockholm Water Company).

شكل (5) يوضح مخطط النقل في منطقة Hammarby Sjöstad
http://remoteconditions.blogspot.com



شكل (8) يوضح مخطط المناطق الخضراء في منطقة (Hammarby Sjöstad)
(Gaffney A. & et al .2007.p53)



شكل (6) يوضح مخطط إستعمالات الارض في منطقة (Hammarby Sjöstad), حيث سيطرة الفعاليات السكنية والفضاءات الخضراء على الغالبية العظمى من إستخدامات الابنية في المنطقة (Goel S.,2013.12)

شكل (7) يوضح لقطة منظورية توضح كيفية إنتشار عناصر البنى الخضراء ضمن الهيكل العام لمنطقة (Hammarby Sjöstad)
(Gaffney A. & et al .2007.p53)

شكل (10) يوضح موقع مدينة (Viikki) من دولة فنلندا, ومن العاصمة هلسينكي (http://www.hel.fi)

شكل (13) يوضح تأهيل الابنية المستدامة في حي (Eco-Viikki)
(http://www.femina.ch)

شكل (11) يوضح مخطط البنى الارتكازية الخضراء في حي (Eco-Viikki)
.(Hakaste H. & et al .2005.p16)

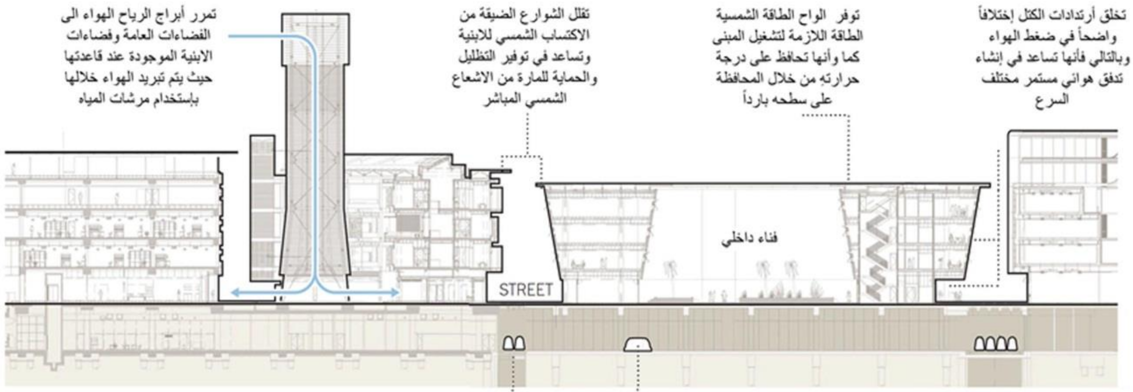
شكل (14) يوضح مخطط مقوم النقل في حي (Eco-Viikki)
(http://www.femina.ch)

شكل (12) يوضح مخطط أستعمالات الارض في حي (Eco-Viikki)
(http://www.hel.fi)

شكل (15) يوضح مخطط الطاقة الشمسية في منطقة (Eco-Viikki)
.(Schulz C.,2006.p21.p2)

شكل (16) يوضح مخطط مدينة مصدر الذي جاء على صيغة تشكيلين مربعين مختلفين في الابعاد (www.flickr.com)

شكل (19) يوضح مخطط النقل في مدينة مصدر المستدامة (ADFEC ,2011,p51)



شكل (17) يوضح مقطع في مدينة مصدر حيث الشوارع الضيقة و المعالجات المستلهمة من التراث العمراني العربي (http://www.nytimes.com)

شكل (18) يوضح مخطط البنى الارتكازية الخضراء في مدينة مصدر (www.flickr.com)

تقييم مشاريع التشييد على اساس التقييم الكمي وباستخدام نظام الخبير

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الخلاصة

يعتبر موضوع تقييم نوعية المشاريع الانشائية من المواضيع المهمة التي يجب ان تولي اهتماماً خاصاً لأهميتها وذلك لغياب المعايير الكمية لقياس أعمال السيطرة والتقييم النوعي للأعمال في مشاريع التشييد حيث ان الواقع الحالي يعتمد على خبرة العاملين والتي تعتمد على اساس الوصف النوعي للعمل مما يؤدي الى حدوث اختلافات واضحة في عملية التقييم.

لقد جاءت فكرة هذا البحث لوضع معايير لتقييم نوعية المشاريع في نظام خاص بالاعتماد على اساس المقياس الكمي وليس النوعي والتوصل الى إعداد نظام خبير لتطبيق هذا النظام باستخدام الحاسوب الالكتروني وبتطبيق نظام الخبير " Crystal " لتمكين المهندسين والمسؤولين ذوي العلاقة من إجراء التقييم النوعي للمشاريع الانشائية بسهولة ودقة وموضوعية اكثر.

Valuation of Construction Projects Based on of Quantity Scale by using Expert System

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ABSTRACT

The subject of an valuation of quality of construction projects is one of the topics which it becomes necessary of the absence of the quantity standards in measuring the control works and the quality valuation standards in constructional projects. In the time being it depends on the experience of the workers which leads to an apparent differences in the valuation.

The idea of this research came to put the standards to evaluate the quality of the projects in a special system depending on quantity scale nor quality specifying in order to prepare an expert system “ Crystal “ to apply this special system to able the engineers to valuate the quality of their projects easily and in more accurate ways.

المقدمة

لايمكن التعبير بسهولة عن جودة العمل الانشائي في الوقت الذي يمر فيه هذا العمل خلال مراحله المختلفة، حيث ان الأمر يتطلب تقييم الجودة (جودة العمل) خلال كل مرحلة على حدة قبل ان يتم التعبير عن جودة العمل الانشائي بشكل شامل.

ان من الامور المهمة التركيز على الاسلوب العلمي والعملي في تقييم عملية تنفيذ المشاريع والاهتمام بجودة المواد المستعملة في التنفيذ وبنوعية وطرق الانشاء وضمان سير العملية التنفيذية في تلك المشاريع بشكل صحيح يخلو من الانحرافات النوعية وذلك لأهمية قطاع التشييد في عملية التنمية والاستثمار عملياً وعالمياً ولكبر حجم هذا الاستثمار في هذا القطاع وفي تشييد المباني بشكل خاص.

ان جميع مراحل التشييد التي يمر بها أي مشروع هي: مرحلة القرار ودراسة الجدوى، مرحلة التصميم، مرحلة الانشاء، ومرحلة التشغيل والصيانة، تعتمد بشكل رئيسي على عمليات تنفيذ المشروع. وحيث ان تنفيذ المشروع ينفق عليه (90 – 95)% من الكلفة الكلية للمشروع (السقا، 1992) لذلك فان مفهوم النوعية وادارتها والسيطرة عليها يمثل حيزاً كبيراً من الاهتمام في الدراسات والبحوث لما للنوعية من تأثير في دقة تنفيذ المشروع.

1- أهداف البحث

يمكن تلخيص أهداف البحث بما يلي:

1-2 صياغة نظام لمعايير التقييم النوعي في قطاع التشييد للمشاريع الانشائية في القطر حيث يمكن اعتماد هذا النظام في تقييم نوعية الاعمال المنفذة . يعتمد هذا النظام على وضع معايير كمية قابلة للقياس اضافة الى الخبرة المتوفرة لدى العاملين ولكن بصورة غير مباشرة اي عدم الاعتماد على الخبرة الشخصية المتراكمة فقط في عملية التقييم. كما ويقترح النظام الاعتماد على اساس شهري كحد ادنى وخصوصاً ان انظمة تقدم العمل للمشاريع بمختلف المجالات والالتزامات المالية الاخرى لها تكون شهرية (شروط المقاولة، 1986) وكما ان هذه المدة تستخدم لقياس التقدم في تنفيذ الاعمال الجارية والفقرا اللاحقة لها بالنظر لأن معظم اعمال التقييم السائدة حالياً تعتمد التقييم الشهري (اي يتم التقييم لنوعية الأعمال في نهاية كل شهر).
ويتضمن هذا النظام وضع حدود لمتطلبات القبول لفقرات التشييد منفردة وللأعمال مجتمعة وذلك لان ذلك يؤدي الى تحسين النوعية بصورة فعالة من اجل الوصول الى مشاريع بمستوى نوعي يتناسب مع التطورات الحاصلة في قطاع التشييد خاصة والتطورات المتسارعة في النشاطات الاخرى العامة.

2-2 إعداد نظام حبير لتطبيق المقترح لمعايير التقييم النوعي للمشاريع بالاعتماد على المعلومات التي تملأ موقعياً في استمارات خاصة تعد بشكل خاص لهذا الغرض.

2- منهجية البحث

من اجل تحقيق اهداف البحث فان منهجية اجراء البحث قد اتخذت المراحل التالية:

1-3 الجانب النظري :

لقد تناول الجانب النظري مراجعة الأدبيات والمصادر والمجلات والمنشورات العلمية لغرض جمع المعلومات الواردة في هذا المجال وما كتب حول هذا الموضوع.

2-3 الجانب العملي :

1-2-3 لقد أنجز الجانب العملي من خلال الاستبيان الميداني وإجراء المقابلات الشخصية مع المعنيين من جهات فنية متخصصة عاملة في هذا المجال لجمع المعلومات والتفاصيل من اجل تحديد صورة واقع الحال لاساليب تقييم نوعية الاعمال ولمعرفة العوامل المؤثرة في نوعية الاعمال وبالاعتماد على نتائج الاستبيان وتحليلها ثم اقتراح نظام لتقييم نوعية الاعمال في المشاريع الانشائية استناداً الى واقع الحال وتطويراً للأساليب المطروحة في الدراسة النظرية.

2-2-3 إعداد استمارات خاصة للتقييم بموجب النظام المقترح تتضمن معلومات تملأ وموقعياً.

3-2-3 إعداد نظام خبير ذو قاعدة معلومات خاصة تستخدم المعلومات الواردة في استمارات التقييم الخاصة لغرض الوصول الى التقييم النهائي.

(الجانب النظري من البحث)

1- المفاهيم الاساسية للنوعية

تعرف النوعية Quality بأنها مجموعة خصائص ومميزات منتج او خدمة ذات صلة بمقدرته على الايفاء بحاجة معينة، وتعرف ايضاً بأنها مجموعة الخصائص والمميزات التي تؤهل منتجاً او خدمة للاستجابة للحاجات الظاهرة والضمنية(القزاز،2000).

اما السيطرة النوعية Quality Control فهي نظام برمجة وتنسيق جهود المجاميع المختلفة في منظمة معينة لغرض المحافظة على النوعية او لتحسينها بطريقة اقتصادية (القزاز،2000) وتعرف ايضاً على انها التقنيات التشغيلية والافعال التي تستخدم للايفاء بمتطلبات النوعية(ACI Committee,1985).

ومن الضروري التذكير هنا بالفرق بين مفهوم السيطرة النوعية (Q.C) ومفهوم توكيد النوعية (Quality assurance) والتي هي عبار ة عن التقنيات النظامية المخططة والضرورية للتأكد من ان المنتوج النهائي يستحق الغرض الذي انتج من اجله. وبعبارة اخرى يمكن القول ان السيطرة النوعية هي اداة انتاج (Production Tool) بينما تمثل توكيد النوعية اداة ادارية (Management Tool) ، وتجدر الاشارة الى ان موضوع البحث يقع في مجال توكيد النوعية.

2- السيطرة النوعية في قطاع التشييد

من الضروري التركيز بأن السيطرة النوعية في قطاع التشييد تختلف نسبياً عن تلك الخاصة بالصناعة وذلك لطبيعة قطاع التشييد والمتمثل بالخصائص التالية(Rounds,et al.,1985):

1-2 ان معظم مشاريع التشييد غير متكررة اي انها تتشابه في خطوطها العامة ولكنها تختلف في كثير من التفاصيل.

2-2 ان مواقع الصناعة ثابتة بينما مواقع التشييد متغيرة من موقع الى اخر.

3-2 ان دورة عمل المنتوج الصناعي قصيرة بينما دورة عمل وعمر العمل الانشائي طويلة قد تصل الى اكثر من (100) سنة لبعض المنشآت.

4-2 عدم وجود مقاييس نظامية لجودة العمل الانشائي مثل تلك الموجودة في قطاع الصناعة.

5-2 بالنظر لكون المنشآت هي منتوج او عمل نهائي فان صاحب العمل قد يتدخل باجراء التعديلات التي يحتاجها اثناء التنفيذ.

6-2 ان جميع اطراف عملية التشييد (المالك، المصمم، المقاول الرئيسي، المقاولين الثانويين، المجهزين) تختلف من مشروع لآخر. يتضح بأن هناك خصوصية في اعمال متابعة النوعية للمشاريع تختلف عن الاعمال النمطية او الصناعات وتتركز على الخبرة المكتسبة من المشاريع السابقة حيث يتطلب التعريف بالملاحظات والنواقص وعدم المطابقة بشكل مبكر لغرض تلافيها اولاً بأول وذلك لصعوبة تصحيح الاخطاء واجراء المعالجات اللاحقة او عند الاستلام والإشغال(قصير، 2000).

(الجانب العملي للبحث)

اولاً : إعداد الاستبيان وتحليله:

1-1تحديد حجم العينة :

لقد تم اخذ عينة عشوائية من مجتمع المعنيين في المجتمع الهندسي ممثلة في عدد من المهندسين بلغ عددهم (50) مهندس وذلك اعتماداً على المواصفة الامريكية ASTM-E122-79 والتي تتضمن تحديد حجم العينة بتطبيق المعادلة التالية :

$$N = (F * S / E)^2$$

حيث ان :

N = حجم العينة

F = معامل فترة الثقة

S = الانحراف المعياري

E = نسبة الخطأ

لقد تم اختيار فترة الثقة مساوية الى (99.7)% وبذلك يكون حجم العينة مساوياً الى (38) مستبين ولزيادة الدقة فقد تمت زيادة حجم العينة الى (50) مستبين من المهندسين. تم اختيار افراد العينة من كوادر علمية وفنية بمختلف الاختصاصات وذوي خبرة في مجال التشييد تزيد على (10) سنوات وكانوا بمناصب ادارية مختلفة بين استاذ جامعي، رئيس قسم، رئيس شعبة، رئيس مهندسين، مهندس اقدم وخبير فني.

1- 2 تصميم اسئلة الاستبيان

لقد تم تصميم استمارة استبيانشملت نوعان من الاسئلة، اسئلة تتعلق بالمستبين ذاته واخرى تتعلق بموضوع تقييم نوعية الاعمال في المشاريع الانشائية كما في الملحق رقم (1) حيث روعي عند تصميم الاستبيان اساسيات التنفيذ لفقرات الاعمال في المشاريع من خلال خبرة الباحثين العلمية والعملية وممارساتهم في مجال التقييم النوعي ومراجعة الدراسات السابقة والأدبيات المتعلقة بالموضوع مع الاستفادة من استقراء التجارب السابقة في عمليات التقييم النوعي في القطاع الصناعي والاستعانة بالمفاهيم السائدة فيه وذلك لان المعنيين في القطاع الصناعي قطعوا مرحلة متقدمة في مجال التقييم النوعي لأعمالهم وذلك بالتركيز على المبادئ الاربعة والمسماة (4m) وهي : المواد materials، العمال Man power، المكائن Machines، وراس المال money، والاسس الحديثة لادارة الجودة في الانتاج(القزاز واخرون).

1-3استخلاص المعلومات وتحليل النتائج

لقد تم جمع اجوبة استمارات الاستبيان ثم تنظيمها في الجدول رقم (1-1) ,(1-2) والذي يوضح فعالية الاجوبة لكل مستبين وذلك لتسهيل الدراسة واجراء التحليل والمقارنة المطلوبة، علماً بأن بعض الاسئلة لم تتم الاجابة عليها وقد بلغت نسبتها اقل من (0.5) % من الاجوبة الكلية وهي نسبة قليلة ومقبولة احصائياً. وبعدها تمت دراسة الاجوبة وكما يلي:

1- لقد اتضح ان (80%) من اجوبة المستبينين كان الاسلوب الامثل المفضل لديهم لتقييم نوعية الاعمال الانشائية المنفذة هو اسلوب (تقييم تفصيلي للفقرات المنفذة) بينما (20%) منها فقط كان الاسلوب الأمثل المفضل لديهم هو (التقييم العام للعمل).
2- لقد كانت النسبة الاكبر من اجوبة المستبينين وهي (56%) تؤكد بأن المبدأ المفضل اتباعه في تقييم الاعمال المنفذة هو مبدأ (الخبرة المتراكمة) بينما (42%) منها تفضل اتباع مبدأ (وجود نظام لتقييم الاعمال) وقد يعزى ذلك الى ان عدد كبير من المستبينين كان من المهندسين ذوي سنوات خدمة طويلة وهذا يعكس تأقلمهم مع مبدأ الاعتماد على خبرتهم المتراكمة في تقييم نوعية الاعمال، رغم ان لديهم الطموح في وضع نظام لتقييم نوعية الاعمال وهذا نجده واضحاً في اجاباتهم عن السؤال الرابع (في استمارة الاستبيان) والموضح التعليق عليها في النقطة (4) ادناه.
3- وبخصوص العوامل التي اختيرت في البحث ايتم اخذها بنظر الاعتبار عند التقييم باتباع مبدأ الخبرة المتراكمة فان نسب عالية من المستبينين أيدوا هذه العوامل حيث ان (70%) من الاجوبة رشحت العامل (جودة المواد الاولية)، (72%) من الاجوبة رشحت العاملين (كفاءة العاملين) و (الاجراءات المتخذة لضمان حسن التنفيذ)، (54%) منها رشحت العامل (نوعية العمل المستلم).
4- لقد اتضح بأن عدد كبير من اجوبة المستبينين (88%) تعتقد بوجود حاجة لوضع نظام لتقييم نوعية الاعمال بينما (12%) منها فقط لاتعتقد ذلك، وهذا يؤكد اهمية موضوع هذا البحث في التوصل الى اقتراح نظام لتقييم نوعية الاعمال الانشائية.
5- من اجل التوصل الى اقتراح اسلوب التقييم فلقد تم جمع اجوبة المستبينين على الاسئلة الخاصة بذلك وتمت دراستها احصائياً وذلك باستخراج التكرار لهذه الاسئلة ضمن الفترات المحددة في الاستبيان وكما موضح في الجدول رقم (2) اعلاه ومن ثم ايجاد قيم المتوسط الحسابي (ابو صالح واخرون، 1983) كأسلوب احصائي بسيط وشائع في الدراسات الاحصائية بتطبيق المعادلة التالية:

$$\text{المتوسط الحسابي} = \frac{\text{مجموع (مركز الفئة * تكرارها)}}{\text{مجموع التكرار}} \quad \text{-----} \ (1)$$

ان الملحق رقم (2) يوضح الحسابات الخاصة بايجاد قيم المتوسط الحسابي حيث تم تقسيم كل فترة من فترات درجات التأثير الى فئات بحيث يكون مركز اول فئة وآخر فئة هو رقم البداية والنهاية لتلك الفترة من فترات درجات التأثير لذلك العامل. لقد تم اقتراح درجات تأثير معينة لكل عامل وبشكل فترات وذلك كدليل يسهل للمسنين تحديد درجة التأثير المطلوبة في تحديد معاملات النظام المقترح.

5-1 العوامل المؤثرة على نوعية العمل المنفذ:

لتوضيح العوامل الفنية المؤثرة فقد تم تنظيم قيم المتوسط الحسابي (نتيجة الاستبيان) لكل عامل من العوامل المؤثرة على نوعية العمل المنفذ في الجدول رقم (2) ادناه حيث ان المتوسط الحسابي يمثل القيمة المثلى لدرجة تأثير ذلك العامل على تقييم نوعية العمل للفقرة المعينة.

5-2 اعمال ادارة النوعية في المشروع :

لقد تم توضيح قيم المتوسط الحسابي (نتيجة الاستبيان) اي القيم المثلى لدرجة تأثير عوامل الادارة النوعية (Round, 1985) على تقييم نوعية العمل المنفذ في المشروع في الجدول رقم (3) والتي تمثل العوامل الادارية المؤثرة.

5-3 درجة تأثير العوامل الفنية والادارية على مجمل النوعية :

لقد تم تنظيم قيم المتوسط الحسابي لدرجة تأثير العوامل الفية والعوامل الادارية على مجمل نوعية الاعمال في المشروع الواردة في الفقرتين (5-1) و (5-2) اعلاه في الجدول رقم (4) .

ثانياً : النظام المقترح لمعايير التقييم النوعي للمشاريع الانشائية :

بعد ان تم التوصل الى العناصر التي تكون الهيكل العام للنظام المقترح لمعايير التقييم النوعي للمشاريع الانشائية، تم اقتراح الصيغة النهائية للنظام المقترح لتكون ممكنة التطبيق من قبل الدوائر ذات الصلة بالموضوع لما في ذلك كمن اهمية وفائدة عامة. لقد تم توضيح الصيغة النهائية للنظام المقترح بأسلوبين وكما يأتي :

الاسلوب الأول : إعداد نموذجين لإستمارات تقييم نوعية المشاريع الانشائية وكما في الملحق رقم (3) حيث تمثل الاستمارة الاولى اسلوب تقييم نوعية الاعمال وفقاً للأبنية التي يتكون منها المشروع الانشائي الواحد، بينما تمثل الاستمارة الثانية اسلوب تقييم نوعية الاعمال وفقاً لفقرات المشروع الانشائي ككل. حيث تملأ المعلومات في تلك الاستمارات موقعياً للاستفادة منها في الاسلوب الثاني، حيث تم تقسيم الاعمال الى ثلاثة فقرات رئيسية هي (اعمال الهيكل، اعمال الانهاءات، واعمال الكهروميكانيك).

من ضمن المعلومات التي تملأ من قبل المهندس المقيم قيامه بتثبيت وزن كل من هذه الفقرات من العمل الكلي لذلك الشهر (اعتماداً على كلفة المشروع) ويتم ذلك (بالاعتماد على المعلومات المتوفرة في تخطيط المشروع من قسم التخطيط الفني للمشروع لاوزان هذه الفقرات) اما في حالة عدم توفر هذه المعلومات فيتم تقديرها من قبل المهندس المقيم حسب خبرته.

الاسلوب الثاني : استخدام الحاسوب الالكتروني وتطبيق نظام الخبير " Crystal " في إعداد نظام بإسم (النظام المقترح لمعايير التقييم النوعي للمشاريع الانشائية) وذلك لتسهيل تطبيق النظام المقترح في هذا البحث من خلال ادخال المعلومات المثبتة في الاستمارات الحقلية المقترحة في الاسلوب الاول.

ان النظام المقترح لمعايير التقييم النوعي للمشاريع الانشائية هو كما يلي :

دليل اوزان التقييم لحقلي للعاملين في التقييم النوعي :

أولاً : درجة تأثير العوامل المؤثرة في نوعية العمل المنفذ – (العوامل الفنية) :

التسلسل	وصف الفقرة	نوع الفقرة		
		اعمال الهيكل	اعمال الانهاءات	اعمال الكهروميكانيك
		وزن العامل – %	وزن العامل – %	وزن العامل – %
1-	المواد الاولية الداخلة في العمل	35	25	39
2-	الادوات والعدد المستعملة في العمل	18	17	16
3-	اعمال الضبط والتشغيل والتنفيذ وكفاءة العاملين	23	25	20
4-	نوعية العمل النهائي المنفذ	17	27	19
5-	اعمال الختم وتلافي النواقص ورفع الانقاض	7	6	6
المجموع		%100	%100	%100

ثانياً : درجة تأثير اعمال ادارة النوعية في المشروع – (العوامل الادارية) :

التسلسل	وصف العامل المؤثر	وزن العامل – %
1-	اسلوب ادارة نوعية الاعمال واصدار التعليمات الخاصة بها للعاملين ومدى تطبيق الاجراءات المطلوبة لضمان الجودة (تكامل الوثائق الفنية، كفاءة العاملين، اجراء الفحوصات ومتابعة النوعية في العمل).	78
2-	اسلوب تنظيم العمل في الموقع والادارة (حركة الآليات والمواد والعاملين ونظافة وتنظيم الموقع).	22
المجموع		%100

ثالثاً : درجة تأثير العوامل اعلاه على مجمل النوعية :

التسلسل	نوع العوامل	وزن العامل – %
1-	العوامل الفنية الواردة في (اولاً) اعلاه .	78
2-	العوامل الادارية الواردة في (ثانياً) اعلاه .	22
المجموع		%100

لقد تم اقتراح نسب معينة لدرجة تقييم نوعية المشروع الانشائي وكما يلي :

النسبة – %	درجة تقييم النوعية	
اقل من (65%)	نوعية الاعمال رديئة	غير مقبول
(65 – 69)%	نوعية الاعمال دون المتوسط	
(70 – 74)%	نوعية الاعمال متوسطة	
(75 – 79)%	نوعية الاعمال جيدة	مقبول
(80 – 84)%	نوعية الاعمال جيدة جداً	
(85 – 89)%	نوعية الاعمال ممتازة	
(90 – 100)%	نوعية الاعمال متميزة (فائقة النوعية)	

لقد تم الاعتماد في اقتراح هذا النظام على دراسة اسس التقييمات لنوعية المشاريع في الشركات المقاولة ونسب التقييم فيها والتي تم تحقيقها مؤخراً خلال سنة (2000– 2002) حيث حققت معظم هذه المشاريع نسبة (70)% فما فوق اي بدرجة (جيد) وقد اقترح البحث زيادة نسبة النجاح الى (75)% للسنوات القادمة وذلك للأسباب التالية:

3–1 رفع الحد الأدنى لنجاح المشروع الانشائي وهذا يمثل نوع من انواع التشدد النوعي ومتابعة ايجابية لتحسين النوعية، لذا فبتطبيق هذا النظام يمكن دفع العاملين للعمل بدقة وحرص أعلى من اجل تحسين نوعية العمل ودفع المشاريع الى تحقيق نتائج نوعية أعلى.

3–2 ان هذا المقترح يعد مؤشراً لتحديد كفاءة العاملين في ذلك المشروع من اجل معرفة مدى امكانية تكليفهم بمشاريع اخرى. فالمشاريع التي تحقق درجة نوعية اعمال عالية يستحق العاملون فيها تكليفهم بواجبات قيادية تنفيذية في مشاريع اخرى والعكس صحيح.

3–3 اختيار مشاريع ذات درجة نوعية عالية لأغراض التمييز في صرف الحوافز والمكافئات.

لقد تم تقييم هذا النظام المقترح باعتماد تطبيقه في مشاريع إحدى الشركات (شركة الفاو للمقاولات كحالة دراسية) وكانت نتيجة التقييم ايجابية.

ثالثاً : وصف النظام الخبير:

توصف الانظمة الخبيرة عادة بأنها انظمة قاعدة المعلومات أو الانظمة التي تستقطب خبرة لخبراء وتختزنها لغرض الإفادة منها، لذلك قد توصف بالمساعدة الذكية Intelligent Assistants. وقد عرف Ficher & Schultz (Ficher,et al. 1991) النظام الخبير بأنه النظام الذي يسمح باجراء محاورة بين الآلة (الحاسوب) والمشغل للحصول على المعلومات بشكل بيانات مشاهدة والتي تساعد في عملية اتخاذ القرارات وإعطاء التوصيات.

3–1 هيكل النظام الخبير:

يتكون هيكل النظام الخبير من اربعة اجزاء او عناصر (Ficher,et al. 1991) وهي :

3-1-1 وسيلة اكتساب المعرفة Knowledge acquisition facility

ان وسيلة اكتساب المعرفة تعني الحصول على المعرفة للمجال المعين بواسطة مصدر ما (عادة انشائي) وبناء هذه المعرفة في نظام حاسوب (Robert, 1986) ، تكتسب المعرفو اما عن طريق :

1- مقابلة الخبراء او
2- معارف مستقاة من الدراسة الميدانية او
3- المعرفة المستقاة من البحوث المعرفية او
4- برامج الحاسوب الخارجية التي تساعد في تقديم البيانات المعرفية للنظام او
5- إعادة النظر في المعلومات التي سبق ان اكتسبها الباحث عن المواضيع المتعلقة بالبحث.

3-1-2 قاعدة المعرفة Knowledge base

تتكون من قواعد صغيرة للمعارف مختلفة نوعياً عن قواعد البيانات وان ادامتها على المدى الطويل يختلف كذلك عن ادامة قاعدة البيانات ولايقل عن ذلك اهميةً، لان قاعدة المعرفة تعتبر كمخزن للمعلومات والتي تتغير بمرور الزمن وذلك بتغير العمل.

3-1-3 ماكنة الاستنتاج Inference engine

وهي المسؤولة عن ادارة النظام والسيطرة على وسائل اتصال المستخدم وعن خزن النعرفة في قاعدتها ثم تحديد اي من المعارف ينبغي استخدامها وتسجيل الاسباب الكامنة وراء كل توجيه ربما يوصي به النظام. ان ماكنة الاستنتاج تحمل الوظيفة نفسها التي يستعملها الخبراء وهي طريقة النقاش المنطقي والتي يستثمرون فيها معارفهم لحل مشكلة ما.

3-1-4 وسيلة اتصال المستخدم User interface

وهي جزء ضروري من النظام الخبير واجبها هو معالجة جميع الاتصالات بين المستخدم والنظام الخبير. عادة ما تعتمد بشكل كبير على طبيعة وسيلة الاتصالات والطريقة التي تستحضر بها المعلومات للمستخدم.

3-2 بناء نظام خبير لتطبيق النظام المقترح لمعايير التقييم النوعي للمشاريع :

لأجل بناء نظام الخبير فقد تم بناء قاعدة المعلومات من قبل مهندس المعرفة (الباحثة) ولمعرفة كيفية استخدامه فان ذلك يتم عن طريق المحاورة بين المشغل والنظام وذلك عند تشغيل النظام الخبير " Crystal " حيث تظهر شاشة الحاسوب قائمة اختيار تتضمن ايعازات البرنامج " Crystal ".

وللدخول الى فايلات النظام الخبير فان على المشغل الضغط على الحرف " F " او اختيار الايعاز " File " ثم الضغط على المفتاح " Return " وبذلك تظهر قائمة اختيار ثانوية . وبعد ذلك يختار المشغل الايعاز " Load Knowledge Base " او الضغط على الحرف "L " لغرض تحميل الملف الخاص بنظام الخبيرلتطبيق معايير التقييم النوعي الذي يظهر ضمن قائمة

اختيار ثانوية اخرى تتضمن جميع الملفات المخزونة. ولغرض تشغيل نظام الخبير هذا فان على المشغل تحويل المؤشر الى الايعاز " Run " حيث ستظهر الشاشات الخاصة بتشغيل النظام الواحدة تلو الاخرى . لقد تم توضيح نموذج من هذا البرنامج في الملحق رقم (4).

رابعاً : الاستنتاجات :

يمكن توضيح ماتم التوصل اليه من استنتاجات في النقاط التالية:

1- لقد تبين بأن عدداً كبيراً من المستبينين يؤيد موضوع البحث بضرورة اتباع نظام معين لتقييم نوعية الاعمال الانشائية من اجل تقييم المشروع الانشائي بشكل دقيق.

2- ان اتباع نظام معين لتقييم نوعية المشاريع يعطي مؤشراً مبكراً للنوعية لغرض معالجة الموقف وذلك لأن النوعية غير الجيدة تسبب مشاكل في المجالات التالية :

2-1 تعثر اعمال الاستلام الاولي والنهائي.

2-2 قبول ورضاء صاحب العمل او المسؤول الاعلى.

2-3 زيادة كلف المعالجات مع الوقت والجهد والصيانة.

2-4 المحافظة على سمعة الشركة.

3- ان الانظمة الخبيرة هي طريقة علمية وعملية لتسهيل تطبيق النظام المقترح اعلاه لمعايير التقييم النوعي والاستفادة منه في تقييم مشاريعنا الانشائية.

خامساً : التوصيات والمقترحات :

يمكن اعتبار هذا النظام كدليل للمعنيين من ذوي العلاقة، لذا نوصي بالعمل به للحصول على تقييم نوعي لمشاريعهم الانشائية، ونقترح ان يكون العمل به لفترة تجريبية معينة يتم فيها تسجيل كافة النتائج.

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جدول رقم (1-1) اجوبة المستبينين للأسئلة (1-4)

السؤال		النسبة المئوية للاجابات
1-	تقييم تفصيلي للفقرات المنفذة	%80
	تقييم عام للعمل	%20
2-	الخبرة المتراكمة	%56
	نظام لتقييم الاعمال	%42
3-	جودة المواد الاولية	%70
	كفاءة العاملين	%72
	الاجراءات المتخذة لضمان حسن التنفيذ	%72
	نوعية العمل المستلم	%45
4-	نعم	%88
	نوعاً ما	%12
	كلا	---

جدول رقم (1-2) : اجوبة المستبينين للسؤال الخامس

السؤال (5)	نوع العامل	درجة تأثير العامل - %	اعمال الهيكل					
اولاً :	1-المواد الاولية الداخلة في العمل	(45-30)	الفترة	32-28	37-33	42-38	47-43	
			التكرار	13	13	10	10	
	2-الادوات والعدد المستعملة في العمل	(30-15)	الفترة	17-3	22-18	27-23	32-28	
			التكرار	18	23	3	2	
	3-اعمال الضبط والتشغيل والتنفيذ وكفاءة العاملين	(30-15)	الفترة	17-3	22-18	27-23	32-28	
			التكرار	6	21	9	8	
	4-نوعية العمل النهائي المنفذ	(25-15)	الفترة	17-13	22-18	27-23		
			التكرار	21	16	7		
	5-اعمال الختم وتلافي النواقص ورفع الانقاض	(15-5)	الفترة	7-3	12-8	17-13		
			التكرار	24	17	5		
	نوع العامل	**درجة تأثير العامل - %**	**اعمال الانهاءات**					
ثانياً:	1-المواد الاولية الداخلة في العمل	(30-20)	الفترة	22-18	27-23	32-28	37-33	
			التكرار	12	17	11	8	
	2-الادوات والعدد المستعملة في العمل	(30-15)	الفترة	17-13	22-18	27-23	32-28	
			التكرار	23	13	9	2	
	3-اعمال الضبط والتشغيل والتنفيذ وكفاءة العاملين	(40-20	الفترة	22-18	27-23	32-28	37-33	42-38
			التكرار	13	17	11	2	5
	4-نوعية العمل النهائي المنفذ	(40-25)	الفترة	27-23	32-28	37-33	42-38	
			التكرار	20	8	3	5	
	5-اعمال الختم وتلافي النواقص ورفع الانقاض	(15-5)	الفترة	7-3	12-8	17-13		
			التكرار	30	8	8		
	نوع العامل	**درجة تأثير العامل - %**	**اعمال الكهروميكانيك**					
	1-المواد الاولية الداخلة في العمل	(50-35)	الفترة	37-33	42-38	47-43	52-48	
			التكرار	14	17	8	5	
	2-الادوات والعدد المستعملة في العمل	(25-15)	الفترة	17-13	22-18	27-23		
			التكرار	29	8	6		
	3-اعمال الضبط والتشغيل والتنفيذ وكفاءة العاملين	(30-15)	الفترة	17-13	22-18	27-23	32-28	
			التكرار	12	18	8	4	
	4-نوعية العمل النهائي المنفذ	(30-15)	الفترة	17-3	22-18	27-23	32-28	
			التكرار	17	16	3	5	
	5-اعمال الختم وتلافي النواقص	(15-5)	الفترة	7-3	12-8	17-13		

	ورفع الانقاض		التكرار	22	16	5		
	العوامل الاداريـــــــــــة							
	1–اسلوب ادارة نوعية الاعمال واصدار التعليمات الخاصة بها للعاملين ومدى تطبيق الاجراءات المطلوبة لضمان الجودة (تكامل الوثائق الفنية، كفاءة العاملين، اجراء الفحوصات ومتابعة النوعية في العمل).	(90–70)	الفترة	72–68	77–73	82–78	87–83	92–88
			التكرار	9	11	19	2	5
	2–اسلوب تنظيم العمل في الموقع والادارة (حركة الآليات والمواد والعاملين ونظافة وتنظيم الموقع).	(30–10)	الفترة	12–8	17–13	22–18	27–23	32–28
			التكرار	5	2	19	11	9
ثالثاً :	1–العوامل الفنية في (أولاً) اعلاه	(90–70)	الفترة	72–68	77–73	82–78	87–83	92–88
			التكرار	10	9	21	2	6
	2–العوامل الادارية في (ثانياً) اعلاه	(30–10)	الفترة	12–8	17–13	22–18	27–23	32–28
			التكرار	6	2	21	9	10

جدول رقم (2) : العوامل الفنية – قيم المتوسط الحسابي (نتيجة لاستبيان) للعوامل المؤثرة على نوعية العمل المنفذ

نوع الفقرة			
أعمال الهيكل			
التسلسل	**نوع العامل**	**الحدود المقترحة لدرجة تأثير العامل – %**	**نتيجة الاستبيان– %**
–1	المواد الاولية الداخلة في العمل	(30 – 45)	35
–2	الادوات والعدد المستعملة في العمل	(15 – 30)	18
–3	اعمال الضبط والتشغيل والتنفيذ وكفاءة العاملين	(15 – 30)	23
–4	نوعية العمل النهائي المنفذ	(15 – 25)	17
–5	اعمال الختم وتلافي النواقص ورفع الانقاض	(5 – 15)	7
المجموع			%100
اعمال الانـهاءات			
التسلسل	**نوع العامل**	**الحدود المقترحة لدرجة تأثير العامل – %**	**نتيجة الاستبيان– %**
–1	المواد الاولية الداخلة في العمل	(20 – 35)	25
–2	الادوات والعدد المستعملة في العمل	(15 – 30)	17
–3	اعمال الضبط والتشغيل والتنفيذ وكفاءة العاملين	(20 – 40)	25
–4	نوعية العمل النهائي المنفذ	(25 – 40)	27
–5	اعمال الختم وتلافي النواقص ورفع الانقاض	(5 – 15)	6
المجموع			%100
اعمال الكهروميكانيك			

التسلسل	نوع العامل	الحدود المقترحة لدرجة تأثير العامل – %	نتيجة الاستبيان– %
1–	المواد الاولية الداخلة في العمل	(50 – 35)	39
2–	الادوات والعدد المستعملة في العمل	(25 0 5)	16
3–	اعمال الضبط والتشغيل والتنفيذ وكفاءة العاملين	(30 – 5)	20
4–	نوعية العمل النهائي المنفذ	(30 – 15)	19
5–	اعمال الختم وتلافي النواقص ورفع الانقاض	(15 – 5)	6
المجموع			%100

جدول رقم (3) : العوامل الادارية – قيم المتوسط الحسابي لأعمال ادارة النوعية في المشروع

التسلسل	نوع العامل	الحدود المقترحة لدرجة تأثير العامل – %	نتيجة الاستبيان – %
1–	اسلوب ادارة نوعية الاعمال واصدار التعليمات الخاصة بها للعاملين ومدى تطبيق الاجراءات المطلوبة لضمان الجودة (تكامل الوثائق الفنية، كفاءة العاملين، اجراء الفحوصات ومتابعة النوعية في العمل).	(90 – 70)	78
2–	اسلوب تنظيم العمل في الموقع والادارة (حركة الآليات والمواد والعاملين ونظافة وتنظيم الموقع).	(30 – 10)	22
المجموع			%100

جدول رقم (4) : قيم المتوسط الحسابي (نتيجة الاستبيان) لدرجة تأثير العوامل الفنية والادارية على مجمل النوعية للأعمال في المشروع

التسلسل	نوع العامل	الحدود المقترحة لدرجة تأثير العامل – %	نتيجة الاستبيان – %
1–	العوامل الفنية	(90 – 70)	78
2–	العوامل الادارية	(30 – 10)	22
المجموع			%100

ملحق رقم (1)

نموذج استمارة استبيان

- التحصيل الدراسي :
- المنصب الاداري :
- عدد سنوات الخبرة في مجال : التنفيذ ☐ التصاميم ☐ التخطيط ☐ الادارة ☐ الإشراف ☐

الاستشارات ☐ المقاولات ☐ .

ضع اشارة (√) أمام العبارة التي تختارها:

1- ماهو الاسلوب الامثل المفضل لديكم لتقييم الاعمال الانشائية المنفذة :

تقييم عام للعمل ☐ تقييم تفصيلي للفقرات المنفذة ☐.

2- ماهو المبدأ المفضل اتباعه في تقييم الاعمال المنفذة :

الخبرة المتراكمة ☐ نظام لتقييم الاعمال ☐ .

3- حدد العوامل التي يتم اخذها بنظر الاعتبار عند التقييم حسب الخبرة المتراكمة :

جودة المواد الاولية ☐ كفاءة العاملين ☐ الاجراءات المتخذة لضمان حسن التنفيذ ☐

نوعية العمل المستلم ☐ اخرى تذكر ☐ .

4- هل تعتقد بوجود حاجة لوضع نظام لتقييم الاعمال ؟

نعم ☐ نوعاً ما ☐ كلا ☐.

5- يرجى دراسة اسلوب التقييم المقترح ادناه بكل دقة وعناية وإعطاء النسب التي تراها مناسبة حسب رأيك :

أولاً : العوامل المؤثرة في نوعية العمل المنفذ – (العوامل الفنية):

يرجى تحديد النسبة التي تراها مناسبة في درجة تأثير العوامل ادناه على تقييم نوعية الفقرة المنفذة :

ت	تفاصيل الفقرة	نوع الفقرة		
		اعمال الهيكل	اعمال الانهاءات	اعمال الكهروميكانيك
1-	المواد الاولية الداخلة في العمل	%(45 – 30)	%(25 – 20)	%(50 – 35)
2-	الادوات والعدد المستعملة في العمل	%(30 – 15)	%(30 – 15)	%(25 – 15)
3-	اعمال الضبط والتشغيل والتنفيذ وكفاءة العاملين	%(30 – 15)	%(40 – 20)	%(30 – 15)
4-	نوعية العمل النهائي المنفذ	%(25 – 15)	%(40 – 25)	%(30 – 15)
5-	اعمال الختم وتلافي النواقص ورفع الانقاض	%(15 – 5)	%(15 – 5)	%(15 – 5)
المجموع		%100	%100	%100

ثانياً : أعمال ادارة النوعية في المشروع – (العوامل الادارية) :

يرجى تحديد النسبة التي تراها مناسبة في درجة تأثير عوامل ادارة النوعية المدرجة أدناه على تقييمنوعية العمل المنفذ في المشروع :

1– اسلوب ادارة النوعية واصدار التعليمات الخاصة بها للعاملين ومدى تطبيق الاجراءات المطلوبة لضمان الجودة (تكامل الوثائق الفنية، كفاءة العاملين، اجراء الفحوصات ومتابعة النوعية في العمل). (70 – 90)% ☐

2– اسلوب تنظيم العمل في الموقع والادارة (حركة الآليات والمواد والعاملين ونظافة وتنظيم الموقع). (10–30)% ☐

المجموع %100

ثالثاً : يرجى تحديد النسبة التي تراها مناسبة في درجة تأثير العوامل ادناه على مجمل النوعية :

1– العوامل الفنية في (اولاً) اعلاه. (70 – 90)% ☐

2– العوامل الادارية في (ثانياً) اعلاه. (10 – 30)% ☐

المجموع %100

ملحق رقم (2)

الحسابات الخاصة بايجاد قيم المتوسط الحسابي لدرجة تأثير العوامل على نوعية العمل

أولاً : العوامل المؤثرة في نوعية العمل المنفذ:

نوع الفقرة : اعمال الهيكل:

العوامل المؤثرة :

1– المواد الاولية الداخلة في العمل :

مركز الفئة	30	35	40	45	المتوسط الحسابي
الفئة	32 – 28	37 – 33	42 – 38	47 – 43	
التكرار	13	10	10	10	%35

2– الادوات والعدد المستعملة في العمل:

مركز الفئة	15	20	25	30	**متوسط الحسابي**
الفئة	17 – 13	22 – 18	27 – 23	3218 – 28	
التكرار	18	23	3	2	%18

3– اعمال الضبط والتشغيل والتنفيذ وكفاءة العاملين :

مركز الفئة	15	20	25	30	**المتوسط الحسابي**
الفئة	17 – 13	22 – 18	27 – 23	32 – 28	
التكرار	6	21	9	8	%23

4- نوعية العمل النهائي المنفذ :

مركز الفئة	15	20	25	المتوسط الحسابي
الفئة	17 − 13	22 − 18	27 − 23	
التكرار	21	16	7	%17

5- أعمال الختم وتلافي النواقص ورفع الانقاض :

مركز الفئة	5	10	15	المتوسط الحسابي
الفئة	7 − 3	12 − 8	17 − 13	
التكرار	24	17	5	%7

نوع الفقرة : اعمال الانهاءات :

العوامل المؤثرة :

1- المواد الاولية الداخلة في العمل :

مركز الفئة	20	25	30	35	المتوسط الحسابي
الفئة	22− 18	27 − 23	32 28	37 − 33	
التكرار	12	17	11	8	%25

2- الادوات والعدد المستعملة في العمل:

مركز الفئة	15	20	25	30	المتوسط الحسابي
الفئة	17 − 13	22 − 18	27 − 23	32 − 28	
التكرار	23	13	9	2	%17

3- اعمال الضبط والتشغيل والتنفيذ وكفاءة العاملين :

مركز الفئة	20	25	30	35	40	المتوسط الحسابي
الفئة	22 − 18	27 − 23	32 − 28	37 − 33	42 − 38	
التكرار	13	17	11	2	5	%25

4- نوعية العمل النهائي المنفذ :

مركز الفئة	25	30	35	40	المتوسط الحسابي
الفئة	27 − 23	32 − 28	37 − 33	42 − 38	
التكرار	20	8	3	5	%27

5- أعمال الختم وتلافي النواقص ورفع الانقاض :

مركز الفئة	5	10	15	المتوسط الحسابي
الفئة	7 − 3	12 − 8	17 − 13	
التكرار	30	8	8	%6

نوع الفقرة : أعمال الكهروميكانيك :

العوامل المؤثرة :

1- المواد الاولية الداخلة في العمل :

مركز الفئة	35	40	45	50	المتوسط الحسابي
الفئة	37 − 33	42 − 38	47 − 43	52 − 48	
التكرار	14	17	8	5	%39

2- الادوات والعدد المستعملة في العمل:

مركز الفئة	15	20	25	المتوسط الحسابي
الفئة	17 − 13	22 − 18	27 − 23	
التكرار	29	8	6	%16

3- اعمال الضبط والتشغيل والتنفيذ وكفاءة العاملين :

مركز الفئة	15	20	25	30	المتوسط الحسابي
الفئة	17 − 13	22 − 18	27 − 23	32 − 28	
التكرار	12	18	8	4	%20

4- نوعية العمل النهائي المنفذ :

مركز الفئة	15	20	25	30	المتوسط الحسابي
الفئة	17 − 13	22 − 18	27 − 23	32 − 28	
التكرار	17	16	3	5	%19

5- أعمال الختم وتلافي النواقص ورفع الانقاض :

مركز الفئة	5	10	15	المتوسط الحسابي
الفئة	7 − 3	12 − 8	17 − 13	
التكرار	22	16	5	%6

ثانياً : أعمال ادارة النوعية في المشروع :

العوامل المؤثرة :

1- اسلوب ادارة النوعية واصدار التعليمات الخاصة بها للعاملين ومدى تطبيق الاجراءات المطلوبة لضمان الجودة (تكامل الوثائق الفنية، كفاءة العاملين، اجراء الفحوصات ومتابعة النوعية في العمل) :

مركز الفئة	70	75	80	85	90	المتوسط الحسابي
الفئة	72 − 68	77 − 73	82 − 78	87 − 83	92 − 88	
التكرار	9	11	19	2	5	%78

اسلوب تنظيم العمل في الموقع والادارة (حركة الآليات والمواد والعاملين ونظافة وتنظيم الموقع) :

مركز الفئة	10	15	20	25	30	المتوسط الحسابي
الفئة	12 − 8	17 − 13	22 − 18	27 − 23	32 − 28	
التكرار	5	2	19	11	9	%22

ثالثاً : العوامل الفنية والادارية المؤثرة على مجمل النوعية :

العوامل المؤثرة :

1- العوامل الفنية الواردة في (اولاً) :

مركز الفئة	70	75	80	85	90	المتوسط الحسابي
الفئة	72 - 68	77 - 73	82 - 78	87 - 83	92 - 88	
التكرار	10	9	21	2	6	%78

2- العوامل الادارية الواردة في (ثانياً) :

مركز الفئة	10	15	20	25	30	المتوسط الحسابي
الفئة	12 - 8	17 - 13	22 - 18	27 - 23	32 - 28	
التكرار	6	2	21	9	10	%22

ملحق رقم (3)

استمارة تقييم نوعية الاعمال للمشروع بموجب الفقرات الإنشائية

المشاريع او المشروع : ______ تأريخ المباشرة : ______

اسم البنـــــــــاية : ______ تأريخ الإنجاز : ______

(تقييم العوامل الفنية)							
رقم البناية ☐						وزن البناية من المشروع - % ☐	
(اعمال الهيكل)							
وصف الفقرة	وزن الفقرة من العمل - %	كفاءة المواد الاولية الداخلة في العمل (%35)	كفاءة الادوات والعدد المستعملة في العمل (%18)	كفاءة اعمال الضبط والتشغيل والتنفيذ كفاءة العاملين (%23)	نوعية العمل النهائي المنفذ (%17)	أعمال الختم وتلافي النواقص ورفع الأنقاض (%7)	المجموع
1-							
2-							
3-							
(اعمال الانهاءات)							
وصف الفقرة	وزن الفقرة من العمل - %	كفاءة المواد الاولية الداخلة في العمل (%25)	كفاءة الادوات والعدد المستعملة في العمل (%17)	كفاءة اعمال الضبط والتشغيل والتنفيذ كفاءة العاملين (%25)	نوعية العمل النهائي المنفذ (%27)	أعمال الختم وتلافي النواقص ورفع الأنقاض (%67)	المجموع
1-							
2-							
3-							

(اعمال الكهروميكانيك)							
وصف الفقرة	وزن الفقرة من العمل – %	كفاءة المواد الاولية الداخلة في العمل (39%)	كفاءة الادوات والعدد المستعملة في العمل (16%)	كفاءة اعمال الضبط والتشغيل والتنفيذ كفاءة العاملين (20%)	نوعية العمل النهائي المنفذ (19%)	أعمال الختم وتلافي النواقص ورفع الأنقاض (6%)	المجموع
1-							
2-							
3-							
(تقييم العوامل الادارية)							
1- درجة تأثير اسلوب ادارة النوعية واصدار التعليمات الخاصة بها للعاملين ومدى تطبيق الاجراءات المطلوبة لضمان الجودة (تكامل الوثائق الفنية، كفاءة العاملين، اجراء الفحوصات ومتابعة النوعية في العمل) لذلك الشهر. (78%)					(20- 90) %		
2- درجة تأثير اسلوب تنظيم العمل في الموقع والادارة (حركة الآليات والمواد والعاملين ونظافة وتنظيم الموقع) . (22%)					(10 – 3-) %		

ملحق رقم (4)

النظام المقترح باستخدام نظام الخبير

Crystal

ان هذا لبرنامج هو نظام مقترح كدليل لمعايير تقييم نوعية العمل لأي مشروع انشائي في نهاية الشهر المعين.

اضغط مفتاح الإدخال

هل التقييم المراد على اساس أبنية ؟ 1- نعم √ 2- كلا

هل التقييم المراد على اساس الفقرات ؟ 1- نعم 2- كلا √

يقوم هذا البرنامج باجراء التقييم على اساس الأبنية

اضغط مفتاح الإدخال للبدء بتشغيل البرنامج

أدخل عدد الأبنية

أدخل رقم البناية

نوع الفقرة : (اعمال الهيكل) للبناية رقم (1)

في حالة عدم وجود اعمال الهيكل أدخل القيم صفر

ماهي درجة تأثيرالمواد الأولية الداخلة في العمل ؟

(30% - 35%) غير مقبول

(35% - 45%) مقبول

%

ماهي درجة تأثيرالمواد المستعملة في العمل ؟

(15% - 18%) غير مقبول

(18% - 35%) مقبول

%

ماهي درجة تأثيراعمال الضبط والتشغيل والتنفيذ وكفاءة العاملين؟

(20% - 25%) غير مقبول

(25% - 40%) مقبول

%

ماهي درجة تأثيرالعمل النهائي المنفذ؟

(25% - 27%) غير مقبول

(27% - 40%) مقبول

%

ماهي درجة تأثيرأعمال الختم وتلافي النواقص ورفع الأنقاض؟

(5% - 6%) غير مقبول

(6% - 15%) مقبول

%

اذن مجموع تأثير العوامل الفنية على أعمال الهيكل للبناية رقم (1) هو:

(%)

ماهو تأثير اعمال الهيكل من العمل الكلي لتلك البناية في ذلك الشهر ؟ (%)

اذن مجموع تأثير العوامل الفنية لأعمال الهيكل للبناية رقم (1) هو:

(%)

نوع الفقرة : (اعمال الانهاءات) للبناية رقم (1) :

فى حالة عدم وجود أعمال الهيكل أدخل القيم صفر

ماهي درجة تأثيرالمواد الأولية الداخلة في العمل؟

(30% - 35%) غير مقبول

(35% - 45%) مقبول

%

اهي درجة تأثيرالمواد المستعملة في العمل؟

(15% - 17%) غير مقبول

(17% - 30%) مقبول

%

ماهي درجة تأثيراعمال الضبط والتشغيل والتنفيذ وكفاءة العاملين؟

(20% - 25%) غير مقبول

(25% - 40%) مقبول

%

ماهي درجة تأثيرالعمل النهائي المنفذ؟

(25% – 27%) غير مقبول

(27% – 40%) مقبول

%

ماهي درجة تأثيراعمال الختم وتلافي النواقص وزفع الأنقاض؟

(5% – 6%) غير مقبول

(6% – 15%) مقبول

%

اذن مجموع تأثير العوامل الفنية على اعمال الانهاءات للبناية رقم (1) هو:

(%)

ماهو تأثير اعمال الانهاءات من العمل الكلي لتلك البناية في ذلك الشهر:

(%)

اذن درجة تأثير العوامل الفنية لأعمال الانهاءات للبناية رقم (1) هو:

(%)

نوع الفقرة : (اعمال الكهروميكانيك) للبناية رقم (1) :

في حالة عدم وجود اعمال الهيكل ادخل القيم صفر

ماهي درجة تأثيرالمواد الاولية الداخلة في العمل؟

(35% – 39%) غير مقبول

(39% – 50%) مقبول

%

ماهي درجة تأثير المواد المستعملة في العمل؟

(15% – 16%) غير مقبول

(16% – 25%) مقبول

%

ماهي درجة تأثيراعمال الضبط والتشغيل والتنفيذ وكفاءة العاملين ؟

(15% - 20%) غير مقبول

(20% - 30%) مقبول

%

ماهي درجة تأثيرالعمل النهائي المنفذ ؟

(15% - 19%) غير مقبول

(19% - 30%) مقبول

%

ماهي درجة تأثيراعمال الختم وتلافي النواقص ورفع الانقاض؟

(5% - 6%) غير مقبول

(6% - 15%) مقبول

%

اذن مجموع تأثير العوامل الفنية على اعمال الكهروميكانيك للبناية رقم (1) هو:

(%)

ماهو تأثير اعمال الكهروميكانيك من العمل الكلي لتلك البناية في ذلك الشهر:

(%)

اذن درجة تأثير العوامل الفنية لأعمال الكهروميكانيك للبناية رقم (1) هو:

(%)

اذن مجموع اوزان الاعمال الفنية هو:

(%)

ادخل وزن البناية من المشروع

%

اذن مجموع اوزان الاعمال الفنية في ذلك الشهرللبناية رقم (1) يساوي (%)

وهكذا تعاد خطوات البرنامج حسب عدد الابنية

وهكذا تعاد خطوات البرنامج حسب عدد الابنية

اذن مجموع مجموع درجات تأثير العوامل الفنية لكافة الابنية يساوي (%)

ان النسبة المناسبة لدرجة تأثير العوامل الفنية على مجمل النوعية بموجب النظام المقترح هي (78%) – اذن وزن الاعمال الفنيةللمشروع في ذلك الشهر : (%)

ان درجة تأثير (اسلوب ادارة نوعية الاعمال واصدار التعليمات الخاصة بها للعاملين ومدى تطبيق الاجراءات المطلوبة لضمان الجودة) على نوعية العمل بموجب النظام المقترح = (78%) – فما هي درجة تأثير ذلك على نوعية العمل لذلك الشهر ؟

%

اذن درجة تأثير اسلوب ادارة نوعية الاعمال هي : (%)

ان درجة تأثير (اسلوب تنظيم العمل في الموقع والادارة (حركة الآليات والمواد والعاملين ونظافة وتنظيم الموقع) على نوعية العمل بموجب النظام المقترح = (22%) – فما هي درجة تأثير ذلك على نوعية العمل لذلك الشهر ؟

%

اذن درجة تأثير اسلوب تنظيم العمل في الموقع هي : (%)

اذن مجموع اوزان عاملي الادارة = (%)

ان النسبة المئوية لدرجة تأثير العوامل الادارية على مجمل النوعية بموجب النظام المقترح هي (22%) – اذن وزن الاعمال الادارية للمشروع فى ذلك الشهر : (%)

ان درجة تقييم نوعية العمل للمشروع في ذلك الشهر : (%)

يمكن مقارنة هذه الدرجة مع النسب المقترحة بموجب النظام:

اقل من (65)% نوعية الاعمال رديئة -------------- العمل غير مقبول

(65 – 96)% نوعية الاعمال دون المتوسط --------- العمل غير مقبول

(70 – 74)% نوعية الاعمال متوسطة ------------ العمل غير مقبول

(75 – 79)% نوعية الاعمال جيدة -------------- العمل مقبول

(80 – 84)% نوعية الاعمال جيدة جداً ----------- العمل مقبول

(85 – 89)% نوعية الاعمال ممتازة ------------- العمل مقبول

(90 – 100)% نوعية الاعمال متميزة (فائقة النوعية) – العمل مقبول