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Comparison between the British and American Methods in Designing Concrete using Local Aggregate in the City of Mosul Preparation

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ABSTRACT

This research included an applied study for the design of concrete mixtures by following the method of the American Concrete Institute (ACl) and the method of the Building Research Center in England (British method) to restriction which of these two methods is more suitable for use and application in the design of concrete mixtures when using local aggregate (gravel and sand taken from the area Badush and Aski Mosul), where job mixes were made using the mixing ratios obtained from these two methods, and a comparative study was made for the properties concrete resulting in the soft state (workability)and the hardened state (compressive resistance), and the results proved the following:

A- In general, when discussing the results according to mixing ratios and workability levels, the method of the Building Research Center in England (the British method) gave higher results than the results obtained by the American Concrete Institute method (the American method) when using the above local aggregate whereas results shown increase in (workability) and Compressive strength. This increase amounts to the percentages shown in the table below:

Compressive strength (%)	Slump test (%)	workability
10.48	14.40	Precipitation = 10-8 cm
12.10	21.40	Precipitation = 18-15 cm

Table (1-1)

B- It is possible to make another comparison, when fixing the proportion of water/cement, it turns out that the method of the Building Research Center in England (the British method) gives higher workability than the method of the American Concrete Institute (the American method) and for the same proportion of cement/ water, the American method gives Higher compressive strength than the British method.

C- The building research center method is a more practical and applicable method more than the American Concrete Institute method because it takes the type of cement, the type of aggregate and other properties of the aggregate (especially particle shape) into consideration more than it is in the American Concrete Institute (ACI) method. The above results were relied upon in designing the appropriate concrete mixture in the Mosul Water Project - Right Coast.

Keywords-- Design, Concrete, Mosul

I. INTRODUCTION

1- Concrete mixtures design:

Concrete consists of mainly cement, and aggregate (sand and gravel) and water. It also contains a percentage of confined or intended voids using additives to concrete. Materials may be added to speed up or slow down the reaction rate, to improve workability, to reduce the amount of water needed for the mixture, to increase strength, or to change other properties [1]. The selection of the proportions of the materials that make up the concrete is to give a reasonable balance and economic in addition to the ease of on-site pouring (Placeability), (durability).

(Strength), (Density) and (Appearance) All of these properties determine the required qualities of concrete according to the surrounding circumstances ,and according to the specifications [4,3,2].

2- Methods used in the design of concrete mixtures:

There are many old and modern methods of designing concrete mixtures [6,5] and the following are these methods:

1- Classical Mix Design methods
- A- (Maximum Density method)
- B- (Minimum Voids method)
- C- (Fineness Modulus method)
- D- (Trial And Error method)
- E- (Nominal mixes)

2- Empirical Mix Design methods:
- A - (Road Note No.4 method)
- B- American Concrete Institute, ACI method
- C- UNESCO method
- D- (Basic Mix method)
- E- (Surface Area and Angularity of aggregate

method

F - (Building Research Establishment, British method 1975)

G- Mix Design for Local Material by Hughes)

H- (Code of Practice, CP: 110 method)

…In this research, the design steps were followed by the methods of the American Concrete Institute (ACI) and the British Building Research Center method, using the riverine local heap located within the boundaries of the city of Mosul

3- Basic considerations in designing mixtures [7]:

1- Cost. |

2- Specifications.

4- Factors affecting the mixing ratio test [7]:

A - Strength

B - Workability: It is related to the process of facilitating the handling of concrete, placing it in its place and giving it the new compaction.

C- The maximum size of the particles or (Maximum heap size) as it depends on the dimensions of the section and the distance between the reinforcing steel bars.

D- grading and type of Aggregate

E- The ratio of aggregate / cement (Richness of mix).

F - Quality Control: It is the accurate control of the mixing procedures and, transporting also placing of concrete. In addition to its treatment and examination.

G- Durability

The design process for concrete mixes goes through the following stages:

1- Cement tests.

2- aggregate tests.

3- Determining the properties of the concrete required in the soft and hard state

4- Suggesting a specific mixing ratio

5- Mixing the materials that make up the concrete from the suggested mixing ratios that is includes the following:

A- Reducing the proportion of cement aggregate (stabilizing the water/cement ratio).

B- Examining the precipitation and comparing it with the required limits.

C- Reduce the amount of mixing water

6- Mixing corrected ratios and measuring workability

7- Casting six concrete sample.

8- Checking the compressive strength of the required construction after performing the treatment

From the above, we noticed that there are many methods for designing concrete mixtures, including old (classical) and experimental ones, but no research or study has been conducted to determine which one of these methods is the most practical and most applicable using local aggregate that are abundantly available in the Tigris River Basin in the Badush and Aski Mosul area.

II. THE PURPOSE OF THE RESEARCH

The main purpose of the research is to make a comparative study between the British Building Research Center method and the American Concrete Institute (ACI) method in designing concrete mixtures to determine which one of these methods are more suitable for use and application by using local aggregate. Finally, the research also included the study of most of the physical properties of the coarse and fine aggregate located within the area referred to above, which were used in the research.

III. SEARCH PLAN

The research included two parts (theoretical and practical).

The practical side: This part of the research included conducting all the physical tests for the coarse and fine heap involved in the design and work of the experimental mixtures which obtained from the theoretical side by following the two methods of designing concrete mixtures referred to above.

IV. MATERIALS USED

1. Cement: Ordinary Portland cement (Type I) was used, produced in Badush Cement Factory, and all physical tests related to it were carried out according to the specifications)ع.ق.م)No. (5) for the year 1984 [8], as shown in Table No. (1-2) |

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Table (1-2): Show physical examinations of Badush cement used in the research:

limits m. NS. P No. (5) for the year 1984	the average	Results	properties	
Minimum 2300	0322	2600 .0332.2350	Smoothness by G/cm2	1
Minimum45 Maximum10	426	60,65,55,7.5,9.0,8.0	Firmness time (vicat device): primary minute final (hour):	0
Minimum15 Minimum23	1571 0470	17.1,17.6,17.3, 26.0,25.8,26.7	Pressure tolerance (NT/m2) 3 days old: 7 days old:	1
Maximum %8.0	271%	0.33,0.30,0.28	Safety (mohammam method) (%):	2

2. Water: Drinking water (liquefied water) was used to mix all concrete mixtures

3. aggregate (coarse and fine): A check was carried out for gradation for coarse and fine aggregate in according to the Iraqi Standard Specifications No. (45) for the year 1984 [9] and the British Specifications{10} B.S (882:1992) Gravel gradation limits are shown in Table No. (1-3), and sand gradation limits are shown in Table (1-4). Specific weight and absorption tests were carried out, compact unit weight and gaps for both aggregate were conducted according to American specifications [11] (ASTM C127, C128, & C129)

As shown in Table No. (1-5)

Table (1-3): The limits of the riverine gravel gradient:

Passing percentage %		**Accumulated Remaining Percentage**	**Sieve Size (mm)**
Specification limits (FINE) (B.S882:1992)(10)	**used aggregate**		
100	100	zero	40
100	100	zero	20
86-51	73	28	10
10-0	6	95	5

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Table (1-4): Sand Gradient Limits:

Passing percentage aggregate used %		**Sieve Size (mm)**
Percentage passing (%) B.S. Limits of specification (MEDIUM) (B.S882:1992)(10)	**used aggregate**	
100	100	10
100	100	5
100-65	80	2.36
100-45	72	1.18
80-25	57	0.6
48-5	21	0.3
10-0	5	0.15

Table (1-5): Physical properties of (coarse and fine) aggregate

soft aggregate	**Coarse aggregate**	**Physical properties**
(MEDIUM)	**(FINE)**	
2.6	2.62	Dry specific weight
2.67	2.65	Specific weight. S.D.D
2.78	2.65	Apparent specific weight
1.81	0.5	Absorption (%)
1882	1667	Compact unit weight (kg/m3)
2.67	6.09	Softness standards

4 - Admixtures: None. the theoretical side: This part of the research included the design of various concrete mixes (with multiple compressive strength and different levels of workability) following the British Building Research Center method and the American Concrete Institute (ACI) method and according to the information obtained from the tests of coarse and fine aggregate taken from the area referred to in the purpose of the research.

Design of concrete mixes [12]:

The mixing ratios of reinforced concrete mixes used in pouring the foundation and roof of a building were calculated by using the concrete mix design methods:

1. The American Concrete Institute (ACI method)

2. The British Building Research Center method so that the following requirement are fulfilled * Coarse aggregate Maximum Size = 20mm +

* Workability (Medium, High)

*Compressive resistance at 28 days of age = (20, 25, 30, 40) NT/mm2

*The minimum distance between the reinforcing steel bars = 10 cm

* aggregate used: a riverine located within the boundaries of the Mosul area**. Design according to the method of the American Concrete Institute (ACI) [13]:** Step One: Calculate the maximum size of the aggregate. Step Two: assessment the amount of mixing water and air containing Step Three: Choosing the water/cement ratio Step Four: Calculate the cement containing Step Five: assessment the coarse aggregate containing. Step Six: Calculating the fine aggregate containing the results obtained by following the American Concrete Institute (ACl) method are shown in Table (1-6)

Table (1-6): Results of the American Concrete Institute (ACI) method.

Required compressive strength (Nt/mm2) Workability								**Workability**
40		30		25		21		
w/c	Mixing ratio	w/c	Mixing ratio	w/c	Mixing ratio	w/c	Mixing ratio	
0.430	1:1.4:2.25	0.550	1:2:2.9	0.620	1:2.4:3.25	0.68	1:2.7:3.5	Medium | slump = (10- 8) cm
0.430	1:1.24:2.2	0.550	1:1.9:2.8	0.620	1:2.2:3.25	0.68	1:2.5:3.5	High slump = (18-15) cm

(maximum aggregate size)= 20mm Gravel: Round and not crushed cement: Portland and normal (0.P.C)

Design according to the British Building Research Center method (14):

Step one: Calculate the target compressive strength (target compressive strength = specific compressive strength + M) where M = domain = k*s (k=1.64)= standard deviation=8 NT/mm2. Step Two: Calculate the free water amount. Step Three: Calculate the proportion of water cement Step Four: Calculate the cement amount Step Five: assessment the total containing of the aggregate Step Six: Calculate the containing of fine aggregate Step Seven: Calculate the containing of the coarse aggregate.

The results obtained by following the method of the British Building Research Center are shown in Table No. (1-7).

Table No. (1-7): Results of the British Building Research Center method

Required compressive strength (Nt/mm2) Workability(compressive strength)								**Workability**
40		30		25		21		
w/c	Mixing ratio	w/c	Mixing ratio	w/c	Mixing ratio	w/c	Mixing ratio	
0.400	1:1.32:2.35	0.480	1:1.7.2.9	0.520	1:1.95:3.20	0.560	1:2.25:3.4	Medium | slump = (10- 8) cm
0.400	1:1.35:2.2	0.480	1:1.75:2.75	0.520	1:2.:3	0.560	1:2.25:3.1	High slump= (15-18) cm

(maximum aggregate size): 20mm Gravel: Round and not crushed cement: Portland , and normal . (0.P.C)

V. EXPERIMENTAL MIXTURES

Experimental laboratory mixtures were made by using local aggregate (gravel and sand) that were completed tests above using the mixing ratios obtained from the method of the American Concrete Institute and the method of the British Building Research Center where laboratory tests were carried out in the manner of(fresh concrete) apparent to measure the workability (slump test) and hardened concrete to measure the compressive s strength. By using cube-shaped models measuring 15 x 15 x 15 cm), where the tests were carried out according to specification ASTM C143-71 for Fresh Concrete and Specification B.S.1881 Part 116/1983 :

For hardened concrete, the results of the experimental mixtures are as shown in Table (1-8) and (1-9) and the diagram (2-1) and (3-1).

VI. DISCUSS THE RESULTS

It is noted from the results of the experimental mixtures recorded in Tables No. (1-8 /A and B) and (1-9/A and B). In general, when discussing the results in according to mixing ratios and levels of workability , the Building Research Center method in England (British method) gave higher results. From the results obtained by the American Concrete Institute method . when using the local aggregate above, where the results showed an increase in the workability and compressive strength, and this increase reaches to the percentages shown in Table No. (1-10) as well as for the same workability ratio that gives more compressive strength as shown in the table with the difference in the ratio of water / cement.

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Table No. (1-10): Percentages of increase in workability and compressive strength

Compressive strength	Slump test	exposed compressive strength (N/mm2)	workability levels
12.05	11.46	21	Slump = (10-8) cm
10.40	17.98	25	
12.77	17.50	30	
6.71	10.67	40	Slump = (18-15) cm
17.40	17.48	21	
15.38	18.25	25	
9.06	23.76	30	
6.57	26.09	40	

On the other hand, it is possible to make another comparison where when fixing the water/cement ratio, it show that the method of the Building Research Center in England (the British method gives higher workability than the method of the American Concrete Institute (American method), while for the same water-cement ratio, the American method gives higher compressive strength From the British method, as shown in the diagram(2-1) and (3-1). It is clear from the design steps followed to the above methods , that the British Building Research Center method is more practical and applicable than the other method because the first method is taken into account / cement type / heap type particls shap ... etc.

VII. CONCLUSIONS

From the results obtained from this research, we conclude the following: The British Building Research Center method for designing concrete mixtures is more suitable for application than the method of the American Concrete Institute (ACI) when using local aggregate (taken from the Badush and Aski Mosul area) in Producing concrete with mixing ratios obtained from these two methods.

The results showed the following: An increase in workability and compressive strength was recorded when producing concrete by using local aggregate with the same Workability by following the method of the British Building Research Center, and this increase in these two characteristics amount to the percentages shown in Table No. (1-11).

Table No. (1-11): Percentage rate of increase

Ratio of increase in compressive strength%	Ratio of increase in Slump test %	Workability
10.48	14.40	Slump = 10-8 cm
12.10	21.40	Slump = 18-15 cm

It should be confirmed here that the British Building Research Center method is more practical and applicable method than the American Concrete Institute method because it takes the type of cement, the type of aggregate and other characteristics of the aggregate (especially particle shape) into consideration more than it is in the American Concrete Institute method (ACI).

- The American method gives a higher compressive strength than the British method for the same ratio of water / Cement, which is an important point in favor of the American method when the origin requires more compressive strength of concrete or more durable.
- Indeed , the containing of cement in the mixture designed in the British method is higher than in the American method.

Especially for the compressive strength of 30 Mega – Pascal, and less, where the increase ranges from 6% for high workability and compressive strength of 30 Mega – Pascal to 16% for medium workability and compressive resistance of 21 Mega –Pascal. Therefore, the British method design requires a higher price due to the increase in the amount of cement, as well as More cement causes more heat emission in cracks in concrete, which makes it not suitable for designing mass concrete and concrete that requires reducing cracks, such as water reservoirs concrete and others.

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