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BEHAVIOR OF FERRO-CEMENT SLABS MODIFID BY POLYMER UNDER LOW VELOCITY IMPACT

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Abstract: Ferro-cement is a type of thin reinforced concrete made of cement-sand mortar mixture with closely spaced of relatively small diameter wire meshes. The main aim of this work was to study investigate the behavior of Ferro-cement slabs under impact loading. A total of 36 Ferro-cement slabs were constructed and tested under low velocity impact, The main parameter considered in the present investigation was number of wire mesh layers, content of (SBR) polymer and height of falling mass (falling velocity).

A special testing rig was used to achieve the impact forces using a falling mass (1300 gm steel ball) dropped from (2.5, 1.2 and 0.83 m) height. (500 ×500×50 mm) slabs were used for each test. The polymer (SBR) was used as a ratio by weight of cement of 3%, 5% and 10%. The number of required blows for caused the first crack and final failure was recorded. The results exhibited that the number of blows which were required to make the first crack and failure, increased with increase of polymer content and number of wire mesh layers.

1- Introduction

Many concrete structures may be subjected to dynamic loads arising from impact of ballistic tornado, generated missile, impulsive loads due to air blasts or wind gusts, as well as from earthquakes and machine vibrations.

Ferro-cement is a composite material used in building with cement, sand, water and wire mesh material. It is fireproof, earthquake safe and does not rust, rot or blow down in storms. It has a broad range of applications which include components in a building, repair of existing building. (1)

Ferro-cement has a very high tensile strength and superior cracking behavior in comparison to reinforced concrete. (2)

Ferro-cement is an attractive material for construction of walls, floors, and roofs for underground structures, underground water tanks, water control devices, canal lining and retaining walls.(3)Other uses for Ferro cement are numerous: construction of boats, barges, shell and folded plate. (4)

Ferro-cement composite has been widely and successfully used for the construction of different structures which include silos, tanks, folded roofing, shells and bearing walls.(5, 6, 7, 8, 9)

2- The Experimental Program

The experimental program was planned to investigate the effect of using polymer on the impact resistance of Ferro-cement mortar slabs with different wire mesh layers.

2-1- Materials:

The cement used through this work was Ordinary Portland Cement type I and it is conform to the Iraqi specification No. 5/1999.(10) Natural yellow sand conforming to the Iraqi Standard N0.45(11) grading requirements (zone-2) was used in production of concrete specimens used in this study. Ordinary drinking water was used for mixing and curing for all specimens. Styrene Butadiene Rubber (SBR) is used as polymer modifier in this study. The polymer (SBR) was used as a ratio by weight of cement of 3%, 5% and 10%.

2-2-Details of the ferro-cement slabs

Four groups of mixes were used in this research. All proportions were (1:2) cement:sand. The details of slabs reinforcement and mix proportion shown in the Table (1) below:

Table (1) :Details of the ferro-cement slabs which are tested in this research.

Symbol	Proportion Cement:Sand (by weight)	Polymer:Cement Ratio %	W/C Ratio %	Number of Wire mesh	Slump Test (mm) According to ASTM[12]
R1	1 : 2	0	0.4	0	48
R2	1 : 2	0	0.4	1	42
R3	1 : 2	0	0.4	2	47
FM1-3%	1 : 2	3	0.37	0	33
FM2-3%	1 : 2	3	0.37	1	34
FM3-3%	1 : 2	3	0.37	2	38
FM1-5%	1 : 2	5	0.35	0	37
FM2-5%	1 : 2	5	0.35	1	37
FM3-5%	1 : 2	5	0.35	2	35
FM1-10%	1 : 2	10	0.3	0	29
FM2-10%	1 : 2	10	0.3	1	31
FM3-10%	1 : 2	10	0.3	2	31

2-3-Mix Preparation:

A mechanical mixer of the capacity (0.1) m^3 operated by electrical power was used, the fine aggregate and cement were added before adding polymer and dry mixing were continued until the dry mix became homogenous, then the polymer was added until all particles are fully coated with polymer and finally water were added and mixing continues until uniform mix is obtained, this procedure is similar to the method used by Ohama. [13]

2-4-Casting, Compaction and Curing:

The molds were lightly coated with mineral oil before use according to ASTM C192-88.[14] Specimens casting was carried out in different layers each layer is of 50mm. Each layer was compacted by using a vibrating table for (15-30) second until no air bubbles emerged from the surface of the mortar, and the mortar is leveled off smooth to the top of the molds.

2-5-Impact Test

Thirty six, 56-day age (500 × 500 × 50) mm slab specimens were tested under low velocity impact load. The impact was conducted using 1300 gm steel ball dropping freely from heights 2.4m, 1.2m and 0.83m. Specimens were placed in their position in the testing frame with the finished face up. The falling mass was then dropped repeatedly and the number of blows required to cause first crack was recorded. The number of blows required for failure (no rebound) was also recorded.

3 - Results and Discussion

3-1- Behavior of Ferro-cement Specimens under Low Velocity Impact:

This test is performed in terms of the number of blows required to cause first crack and ultimate failure. The test was applied on square slabs of dimensions (500 × 500 × 50 mm) subjected to repeated impact blows by falling mass (1300 gm) dropped from three heights (2.4 m) , (1.2 m) and (0.83 m) at 56 day age.

The increase in impact resistance at first crack and ultimate failure are plotted in Figures (1) to (3) for all concrete mixes at age of (56) days. From Figures mentioned before, it can be seen that the specimen which reinforced with one layer of wire mesh needed to number of blows to cause a first crack and ultimate failure more than unreinforced specimen and the specimen which reinforced with two layers of wire mesh needed to number of blows to cause a first crack and ultimate failure more than unreinforced specimen and the specimen which reinforced with one layer.

This may be attributed to that Ferro-cement exhibited continuous increasing in impact resistance with increases in volume of reinforcement. [15] Also, results demonstrated that the increase in (P/C) ratio leads to that the increase in impact resistance at first crack and ultimate failure especially at (P/C) ratio (10%) compare with reference concrete. This may be attributed to that the polymer itself has excellent impact resistance. [15] This behavior may be ascribed to the significant reduction in water content of the Ferro-cement slabs caused by inclusion of this type of admixture; the internal bond strength of Ferro-cement is dramatically increased leading to a significant increase in internal energy of concrete (impact resistance).

For (2.4) m height falling mass, the maximum value of the number of blows to cause a first crack was 15 blow for specimen which reinforced with two layers of wire mesh while the maximum value for the number of blows to cause ultimate failure was 38 blow for specimen which reinforced with two layers of wire mesh, both values were by addition (10%) polymer. The percentage increase of number of blows to cause first crack were (33.33 %), (33.33 %) and (66.67%), while the percentage increase in the impact resistance at ultimate failure were (28.57%), (14.28%) and (100%) for unreinforced Ferro-cement slabs with wire mesh and modified with (P/C) ratios (3%), (5%) and (10%) respectively when compared with reference concrete , the percentage increase of number of blows to cause a first crack were (33.33 %), (33.33 %) and (83.33 %), while the percentage increase in the impact resistance at ultimate failure were (0%), (47.05%) and (70.58%) for reinforced Ferro-cement slabs with one layer of wire mesh and modified with (P/C) ratios (3%), (5%) and (10%) respectively when compared with reference concrete ,and the percentage increase of number of blows to cause a first crack were (12.5%), (50%) and (87.5%), while the percentage increase in the impact resistance at ultimate failure were (28.57%), (57.14%) and (80.95%) for reinforced Ferro-cement slabs with two layers of wire mesh and modified with (P/C) ratios (3%), (5%) and (10%) respectively when compared with reference concrete.

For (1.2) m height falling mass, the maximum value of the number of blows to cause a first crack was 21 blow for specimen which reinforced with two layers of wire mesh while the maximum value for the number of blows to cause ultimate failure was 53 blow for specimen which reinforced with two layers of wire mesh, both values were by addition (10%) polymer.The percentage increase of number of blows to cause first crack were (60%), (60%) and (120%), while the percentage increase in the impact resistance at ultimate failure were (11.11%), (55.55%) and (15.5%) for unreinforced Ferro-cement slabs with wire mesh and modified with (P/C) ratios (3%), (5%) and (10%) respectively when compared with reference concrete , the percentage increase of number of blows to cause first crack were (33.33%), (44.44 %) and (88.88 %), while the percentage increase in the impact resistance at ultimate failure were (14.81%), (51.85%) and (74.07%) for reinforced Ferro-cement slabs with one layer of wire mesh and modified with (P/C) ratios (3%), (5%) and (10%) respectively when compared with reference concrete and the percentage increase of number of blows to cause first crack were (-20%), (6.67%) and (40%), while the percentage increase in the impact resistance at ultimate failure were (11.11%), (22.22%) and (47.22%) for reinforced Ferro-cement slabs with two layers of wire mesh and modified with (P/C) ratios (3%), (5%) and (10%) respectively when compared with reference concrete.

For (0.83) m height falling mass, the maximum value to the number of blows to cause a first crack was 27 blow for specimen which reinforced with two layers of wire mesh while the maximum value for the number of blows to cause ultimate failure was 102 blow for specimen which reinforced with two layers of wire mesh, both values were by addition (10%) polymer.The percentage increase of number of blows to cause first crack were (55.55%), (88.88%) and (88.88%), while the percentage increase in the impact resistance at ultimate failure were (28.57%), (66.67%) and (123.81%) for unreinforced Ferro-cement slabs with wire mesh and modified with (P/C) ratios (3%), (5%) and (10%) respectively when compared with reference concrete , the percentage increase of number of blows to cause first crack were (-5.88%), (23.53%) and (35.29%), while the percentage increase in the impact resistance at ultimate failure were (41.86%), (72.09%) and (79.06%) for reinforced Ferro-cement slabs with one layer of wire mesh modified with (P/C) ratios (3%), (5%) and (10%) respectively when compared with reference concrete and the percentage increase of number of blows to cause first crack were (0%), (9.09%) and (22.72%), while the percentage increase in the impact resistance at ultimate failure were (21.82%), (67.27%) and (85.45%) for reinforced Ferro-cement slabs with two layers of wire mesh and modified with (P/C) ratios (3%), (5%) and (10 %) respectively compare with reference concrete.

From the figures mentioned, it can be seen that the impact resistance represented by number of blows until failure decreases with the increasing in falling mass height. That might be due to an increase in strike force with an increase in falling mass height, and that means an increase in the absorbed energy by Ferro-cement slab body in each strike, and this leads to distribution of the total impact energy on the fewer number of blows until failure.

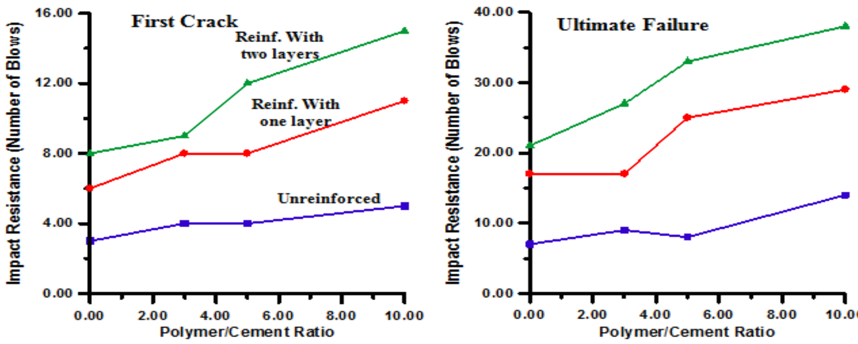

Fig. 1 : Relationship Between (P/C) Ratio and Number of Blows to Cause a First Crack and Ultimate Failure for 2.4 m High Falling Mass.

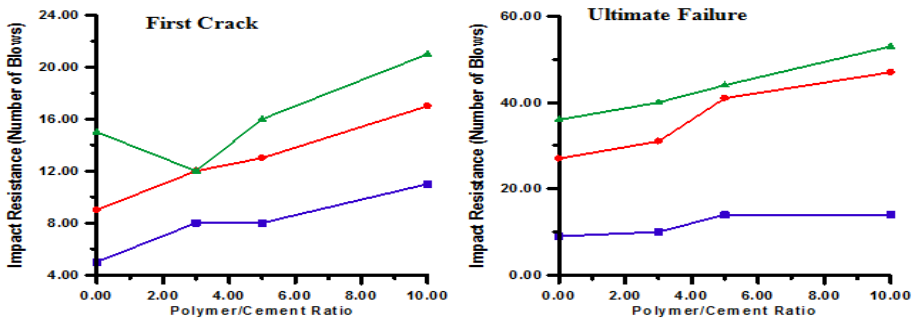

Fig. 2 : Relationship Between (P/C) Ratio and Number of Blows to Cause a First Crack and Ultimate Failure for 1.2 m High Falling Mass.

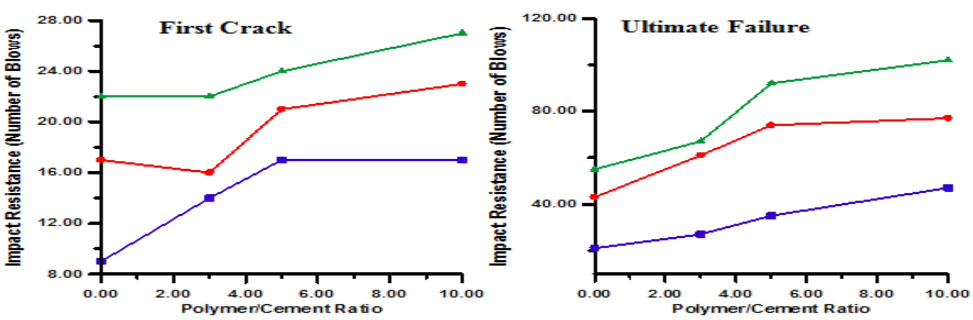

Fig. 3 : Relationship Between (P/C) Ratio and Number of Blows to Cause a First Crack and Ultimate Failure for 0.83 m High falling mass.

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