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THE SELF COMPACTING CONCRETE RESPONSE DUE TO THE EFFECTS OF DIFFERENT DYNAMIC LOADINGS

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Key Words: Impact Repeated load, Quaking Load, Self-Compacting Concrete (SCC), Conventional Concrete (NCC), Light Aggregate Concrete (LAC).

Synopsis

Two types of concrete models; they are flat and convex models made of three types of concrete mixes; they are Self- Compacting concrete (SCC), Conventional Concrete (NCC), and Light Aggregate Concrete mixes are tested against the effect of dynamic loads (repeated impact loads and quaking loads). The flat concrete models lose 33.29%, 68.91%, 66.66% of the initial compressive strength under the effect of the repeated impact loads with energy of 40KJ, 14KJ, and 10KJ for SCC, NCC, and LAC mixes respectively. The convex concrete models lose 33.26%, 56.93%, 46.66% of their compressive strength under the effect of the repeated impact loads with energy of 44KJ, 18KJ, and 11KJ for SCC, NCC, and LAC mixes respectively.

The flat concrete models lose 10.1%, 28.2%, 43% of the initial compressive strength under the effect of the quaking loads with operation time of 4300hrs, 2500hrs, and 1700hrs for SCC, NCC, and LAC mixes respectively. The convex concrete models lose 6%, 21%, 29.6% of the initial compressive strength under the effect of the quaking loads with operation time of 4300hrs, 2500hrs, and 1700hrs for SCC, NCC, and LAC mixes respectively. The current study indicates that the concrete models made of self-compacting concrete mixes offer a good mechanical performance and less loses of the initial compressive strength under the effect of dynamic loads

The convex concrete models reflect a better resistance to dynamic loads comparing with flat concrete models

Introduction

A considerable progress in the technology of concrete manufacturing, especially in the end of nineteenth and the beginning of twentieth century has taken place. Many researchers study, outline, and contribute among them David and mahmoud [1] study the methods for reducing seismic effects of earthquake such as connection design and detailing affect the response of reinforced concrete members in moment resisting frames. He proved that properly detailed connections allow concrete members to develop full flexural capacity resulting in ductile failure in flexural mode instead of brittle shear failure at the connections. Ravindrarajah. and Lyte [2] compare two structural grades of concrete; compressive strength of 30 and 45MPa, normal weight concrete and lightweight polystyrene concrete are tested for their impact response under 75kg weight test through 462mm drop. A load-time plot and the results are used to evaluate the concrete impact response. Peak load and contact time are the dominant quantities in identifying the energy absorbing capacity of concrete. The results show the tested impact loading condition, polystyrene concrete have the compressive strength of 30MPa and show 28% increase in the contact time and 18% reduction in the peak load compared to the similar grade normal weight concrete. Mohamed and Nabilah [3] report that different dynamic loading ranges of 40%-10%, 60%-10% and 85%-10%; are based on the ultimate static failure. Cube compressive strength, beam crack pattern and deflection rates are obtained and compared with both types of concrete. It is found that the fatigue and ductility strength of SCC beams were higher than the NC beams.[4] presents the results of investigations into the failure of four self-compacting concretes under compression. The results are used to calculate the fatigue strength of the tested self-compacting concretes to erect structures subject to expected future dynamic loads.

Research Significance

After the Arabian Gulf War, Iraq Country has been exposure to many huge social and economic problems, among them; a corruption and destroying of electrical energy over all the country. Population in Iraq extremely suffered the problem of electricity ceasing supply for a long time. Accordingly, people began searching for other options rather than the national electrical supply to provide minimum requirements of electrical energy. Electrical generators are a suitable temporary option. Most of the people choose the roof of their buildings to setup electrical generators. The daily production of electrical generators by such machines for a long period of time is accompanied with much quaking loads on the concrete members of the building resulting cracks to the roofs. Since this problem is permanent and persisting nowadays, becomes necessary to study the effects of such dynamic loads on concrete members to take into account the bad effects of such loads.

Purposes of Study

The evaluation of the deterioration of the concrete members due to the exposure of dynamic loads which may be composed of two types; they are 1) repeated impact loads and 2) quaking loads. The study requires considering the following purposes:-

1- Prepare concrete members as models to be tested later on.
2- Curing these models for 90 days to obtain the final compressive strength before test.
3- Evaluation the compressive strength of concrete models (made of SCC, NCC, and LAC))under the repeated impact loads.
4- Evaluation the compressive strength of concrete models under the effect of quaking loads

Conceptualization of the Work

The work begins with the many sequential steps:-

1- Model preparation.
2- Mixes design and proportions.
3- Technology of Testing.

Model Preparation

Four reinforced concrete models are adopted depending on the type of dynamic loads; they are:-

I) Repeated impact loads

A- An repeated impact load of 4.5kg with free falling distance of 45cm on a horizontal reinforced concrete member of the same dimensions as shown in Fig.(1)

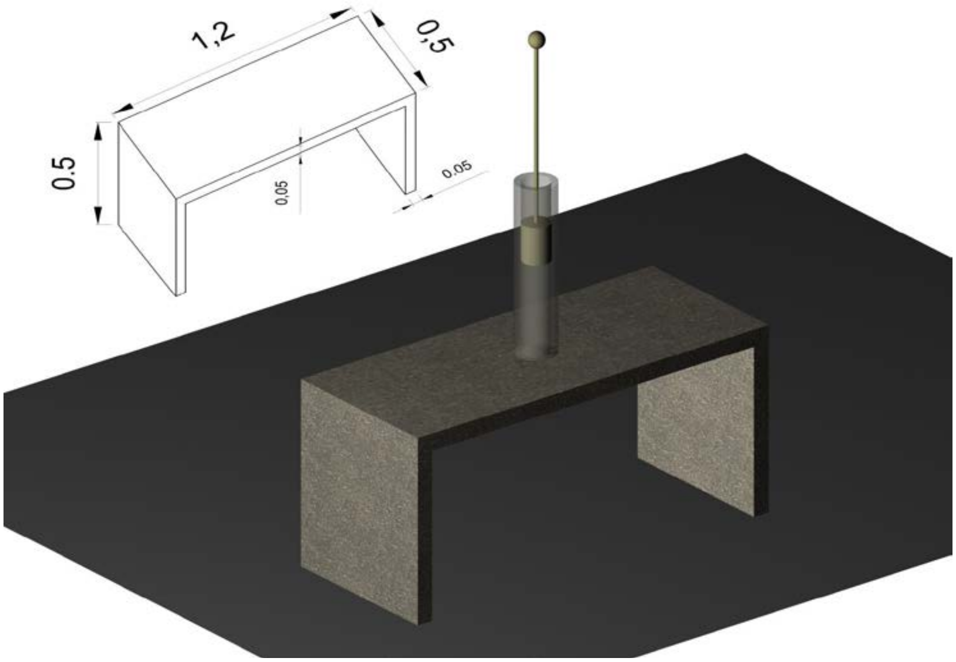
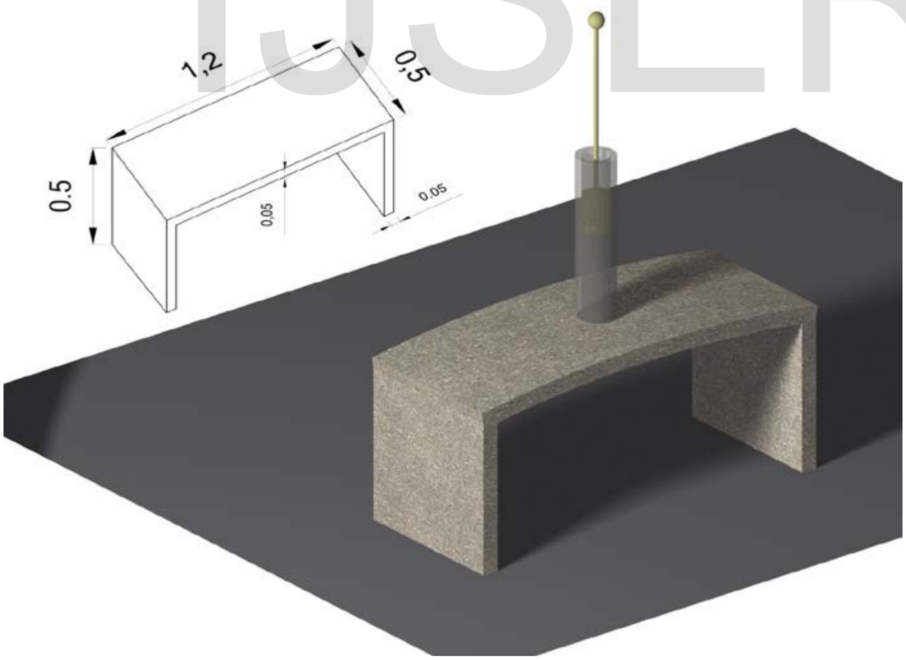


Fig.(1) Impact Load of 4.5kg Falling 45cm on a Horizontal Reinforced Concrete Member

B- An repeated impact load of 4.5kg with free falling distance of 45cm on a curved convex concrete model of the same dimensions as shown in Fig.(2).



C- Fig.(2) Impact Load of 4.5kg Falling 45.7cm on a Curved Reinforced Concrete Member

D- Quaking Loads:-

A) Quaking load of 30kg exerted on a flat and horizontal model with the dimensions of (1.2m Length x Width 0.5m x Thickness 0.05m) fixed on two reactions with the dimensions (0.5m Width x 0.05 Thickness) as shown in Fig. (3).

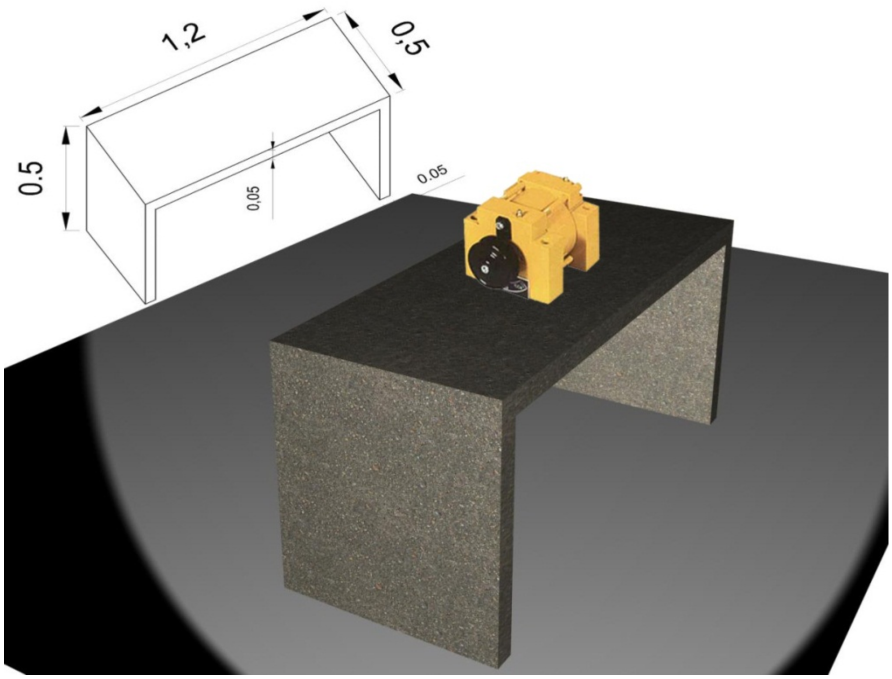


Fig.(3) Horizontal Reinforced Concrete Member exposed to quaking loads of 50kg

B) Quaking load on a curved convex concrete model with same plain dimensions and a radius of curvature equals to 5m as shown in Fig.(4)

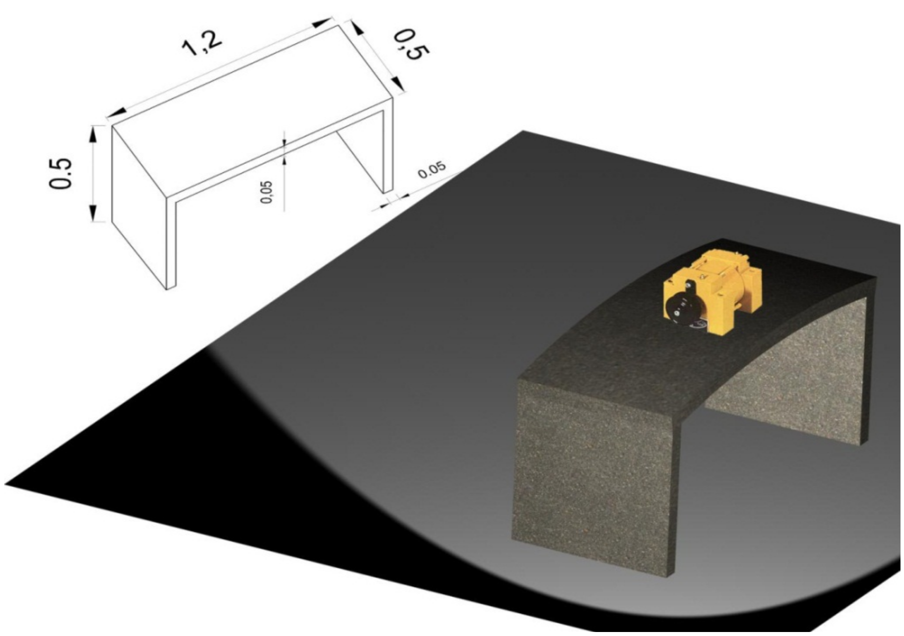


Fig.(4) Curved Concrete Model Exposed to Quaking Loads of 50kg

Energy Equation

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Impact loads have exerted on the concrete models with a specific dynamic energy which may be calculated by:

$$Energy = \frac{w*d}{1000} * No.of\ Blows \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (1)$$

Where: w is the mass in kg, and d is the falling distance in meters

$$Energy = \frac{44.5N*0.457m}{1000} * No\ of\ Blows\ (Kilo\ jule\ , KJ) \ldots\ldots\ldots\ldots(2)$$

Mixes Proportions

Three types of mixes are selected in this research to be analyzed; they are designed and listed herein.

Table (1) shows the mix proportions of NCC, SCC, and LAC mixes used to build the reinforced concrete models

Table (1) Mixes Proportions

Item	NCC	SCC	LAC
Cement, kg/m^3	425	425	425
Sand, kg/m^3	600	750	210
Gravel, kg/m^3	800	800	400
Water, kg/m^3	170	180	180
Superplasticizer, litter		5	5
W/C ratio	0.4	0.42	0.4
Limestone Powder, kg/m^3		160	

Prepared by the Author, 2012

***Note:** Portland cement is used to design the NCC, SCC and LAC mixes. The gradations of the sand and gravel are chosen within the middle of Iraqi Specifications Range (IQS 45/1984).*

Technology of Testing

The mixes of SCC, NCC and LAC are designed and mixed carefully to:-

1- Prepare twelve models, four models for each mix.
2- The four concrete models for each mix are compose of two concrete models for convex and two for flat
3- Prepare three sets (each set is composed of 3 cubes) of concrete cubes for each mix to be tested in 28, 56, 90 days for comparison purposes with the considered concrete models.

Compressive strength Results

The sets of cubes for each mix are tested for the corresponding 28, 56, and 90 days and the results are shown in Fig.(5). Fortunately, the final compressive strength of the cubes and foe the concrete model are found to be coincident.

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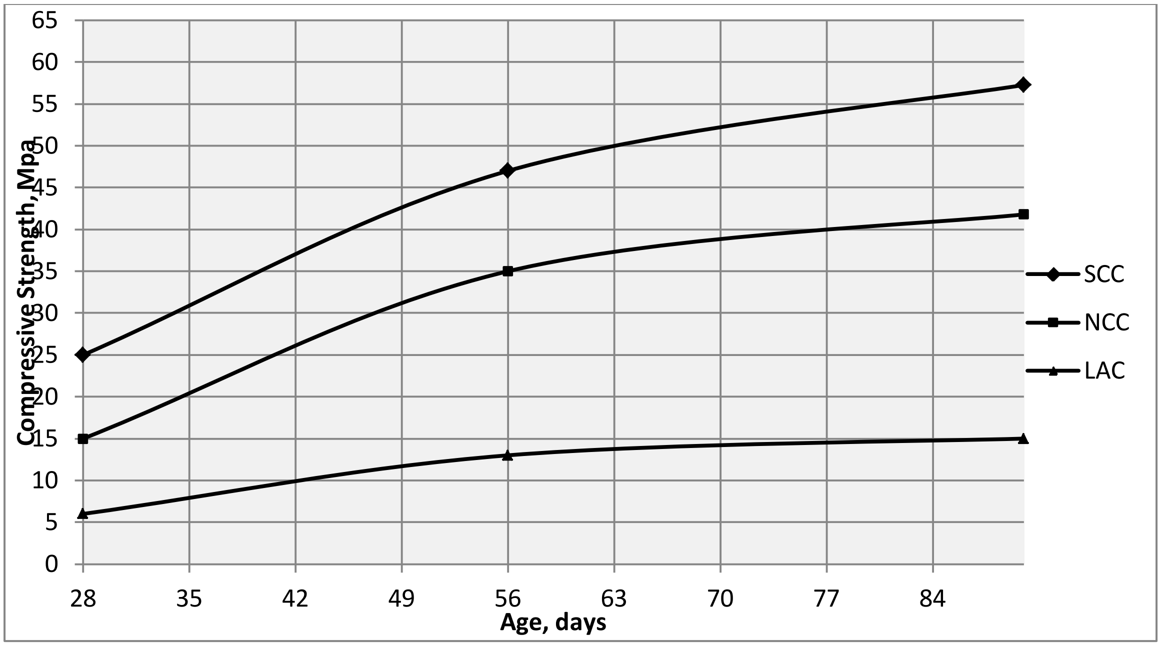

Fig.(5) Compressive Strength Results of the Considered Mixes

Testing Methodology

After the final compressive strength of the concrete models has been obtained in the age 90 days as presented in Fig.(5), the followings tests are carried out:-

1- Impact Loads Testing
   The reinforced concrete models are tested for compressive strength by an *Ultra Sonic Device* technique per number of weight drop for NCC, SCC and LAC mixes.
2- Quaking Loads Testing
   The reinforced concrete models are tested for compressive strength by an *Ultra Sonic Device* technique per hours of operations for NCC, SCC and LAC mixes.

Repeated Impact Loads Results

The flat and arc concrete models are tested against the repeated impact loads and the compressive strength results versus the applied energy of the flat and convex concrete models for the selected three mixes are represented in Fig. (6) and Fig.(7) respectively.

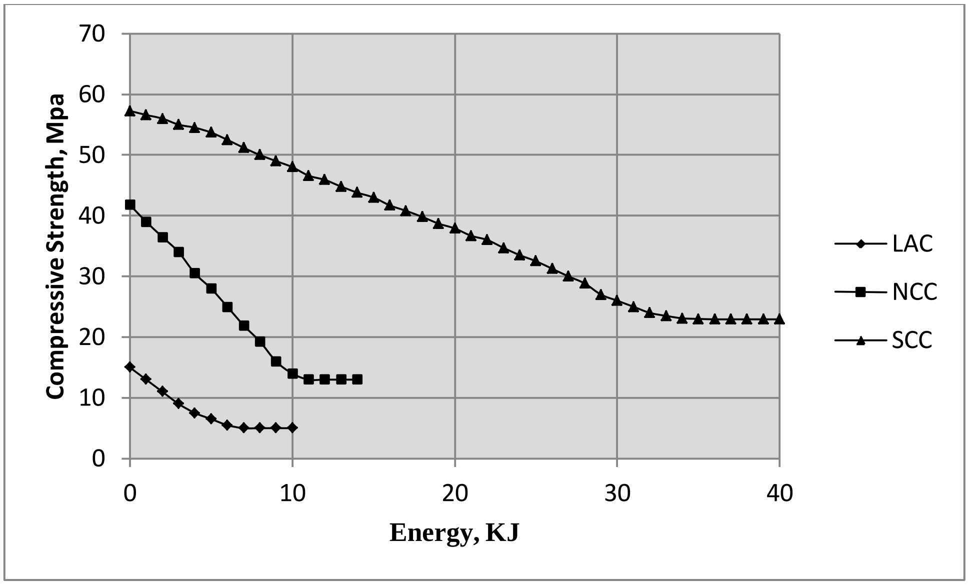

Fig.(6) Compressive Strength of Repeated Loads versus the applied Energy of Flat Concrete Models

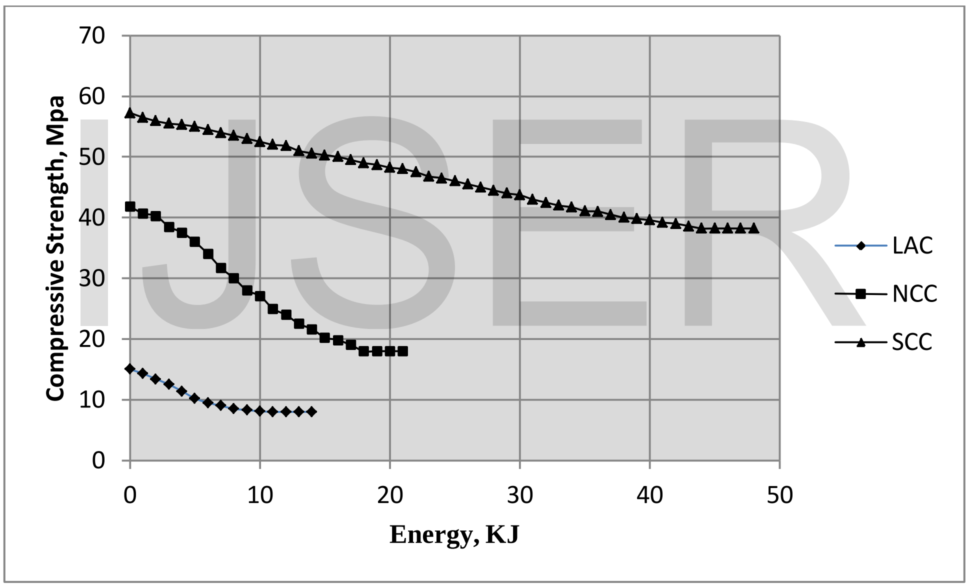

Fig.(7) Compressive Strength of Repeated Loads versus the applied Energy of Convex Concrete Models

For more illustration, it is preferred to to compare the residual compressive strength under the effect of the repeated loads for the flat and convex concrete models separately for each specified mix. The results are represented in Figs (8, 9, and 10)

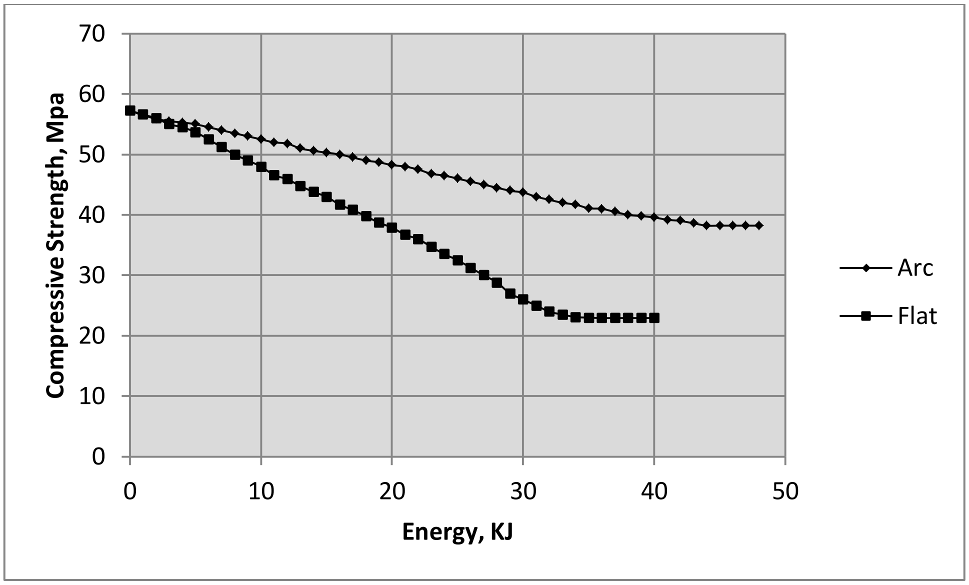

Fig.(8) Compressive Strength versus the Dynamic Energy of the Flat and Convex Concrete Models for SCC Mixes

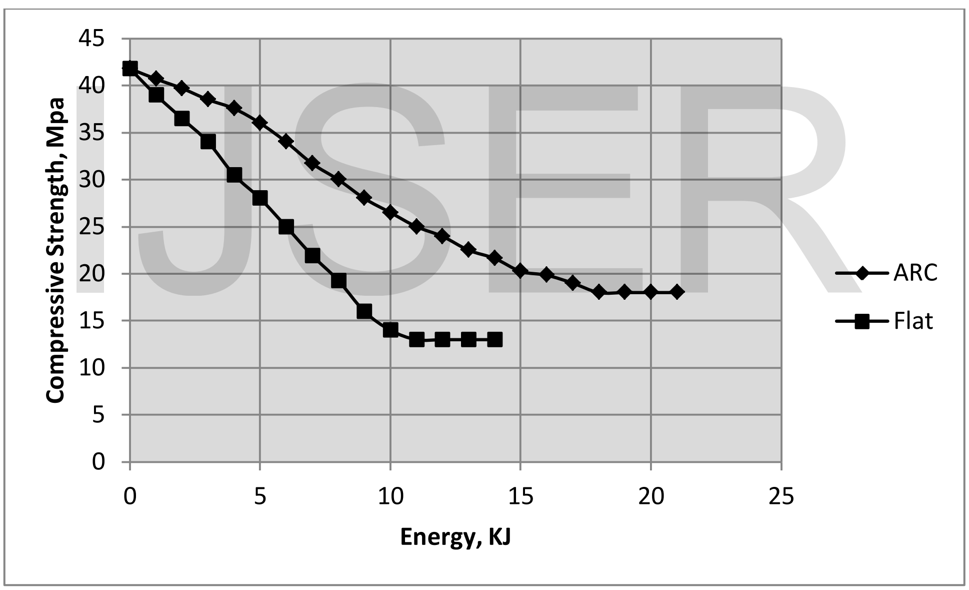

Fig.(9) compressive strength versus the Dynamic Energy of the Flat and Convex Concrete Models for NCC Mixes

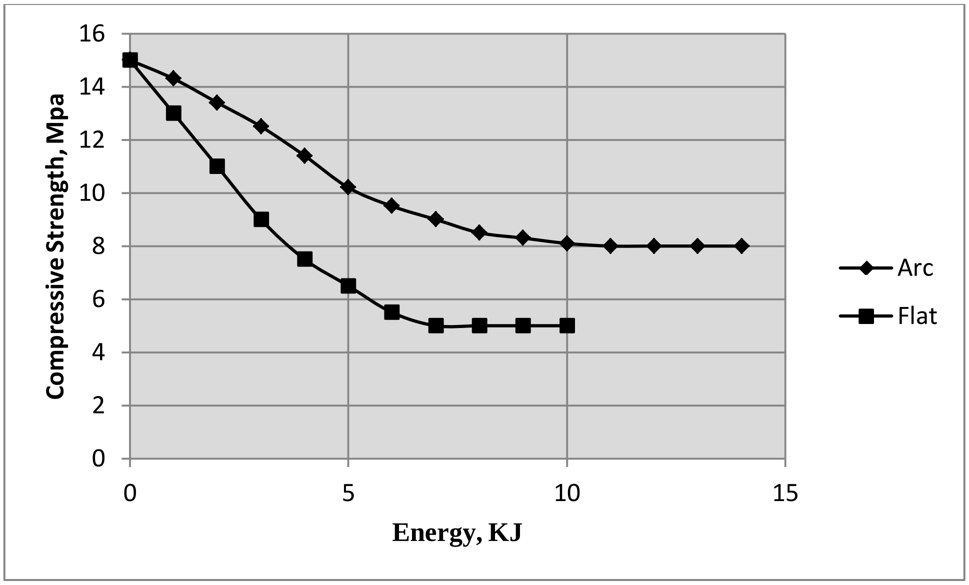

Fig.(10) compressive strength versus the Dynamic Energy of the Flat and Convex Concrete Models for LAC Mixes

Quaking Loads Results

The concrete models (flat & Convex) which is made of the SCC, NCC, and LAC are exposed to quaking loads and the estimated residual compressive strength by using Ultra Sonic Device and the elapsed time are recorded and represented graphically in Figs.(11 & 12).

For more illustration, the physical effect of the repeated impact and quaking loads are separately compared for each type of concrete mix. This indicated in Figs (13, 14, & 15)

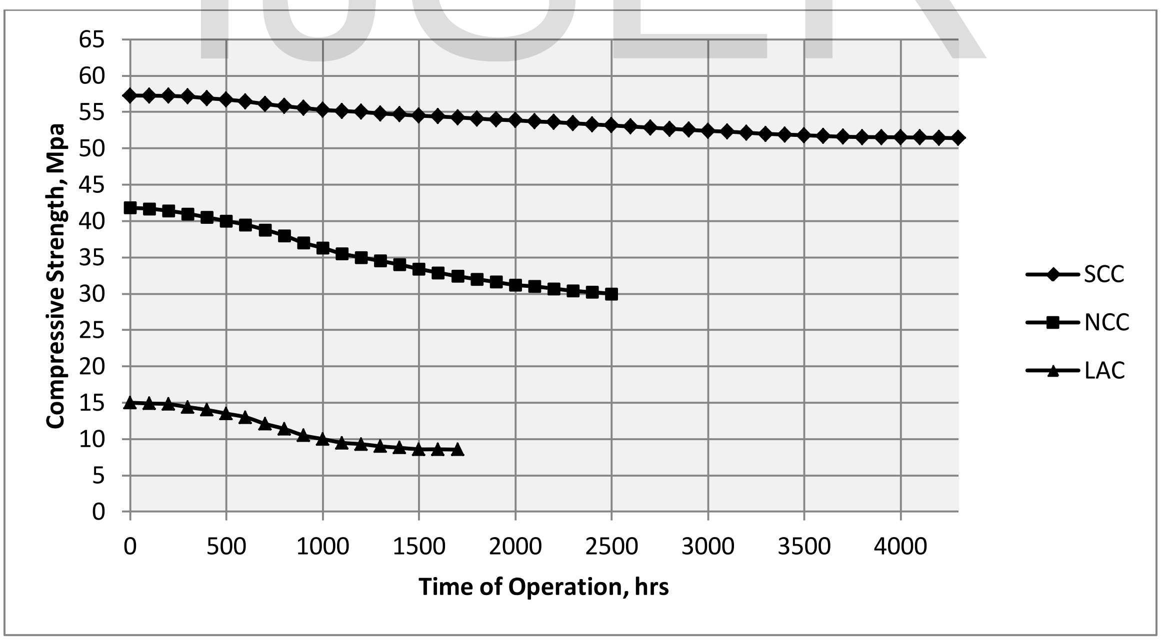

Fig.(11) Compressive Strength of Quaking Loads versus Time of operation for the Flat Concrete Models

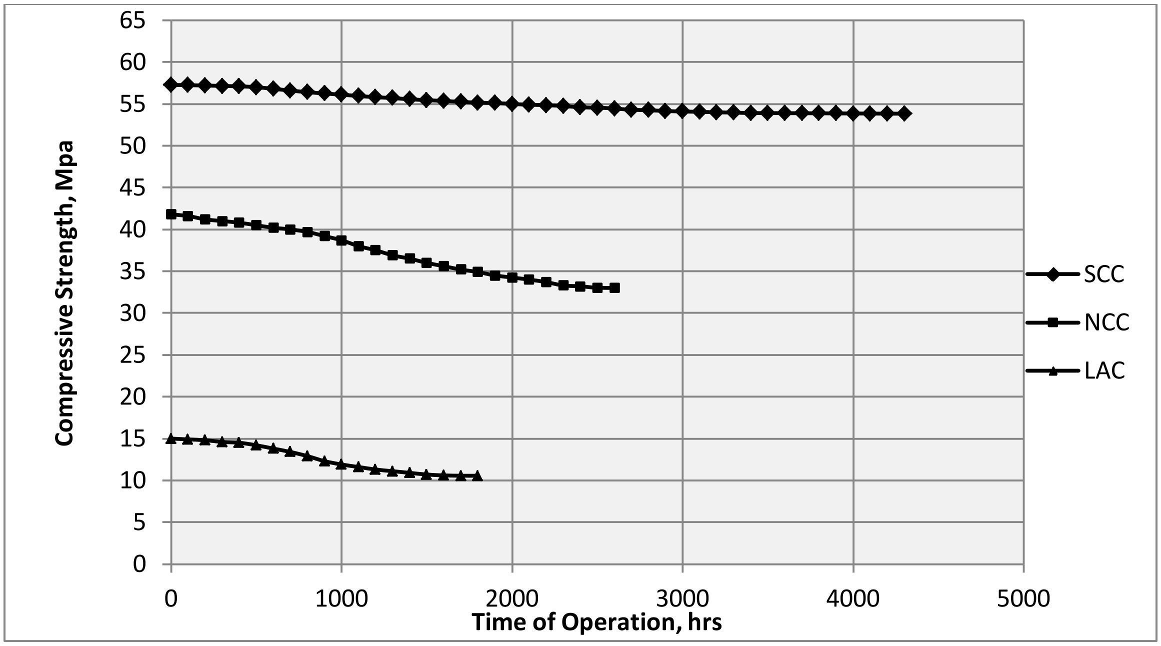

Fig.(12) Compressive Strength of Quaking Loads versus Time of operation for the Convex Concrete Models

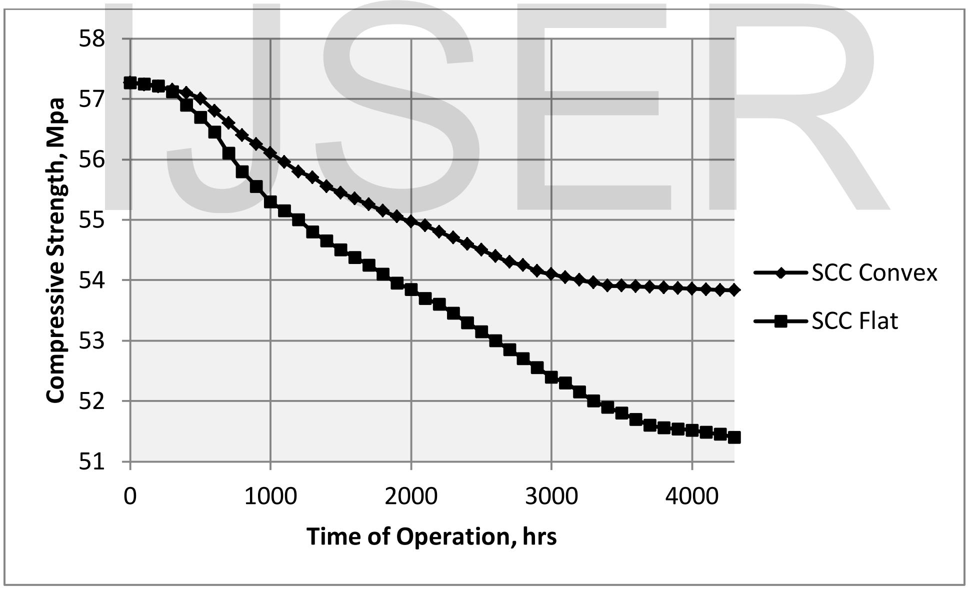

Fig.(13) Compressive Strength of Quaking Loads versus Operation Time of Flat and Convex Concrete Models for SCC Mixes

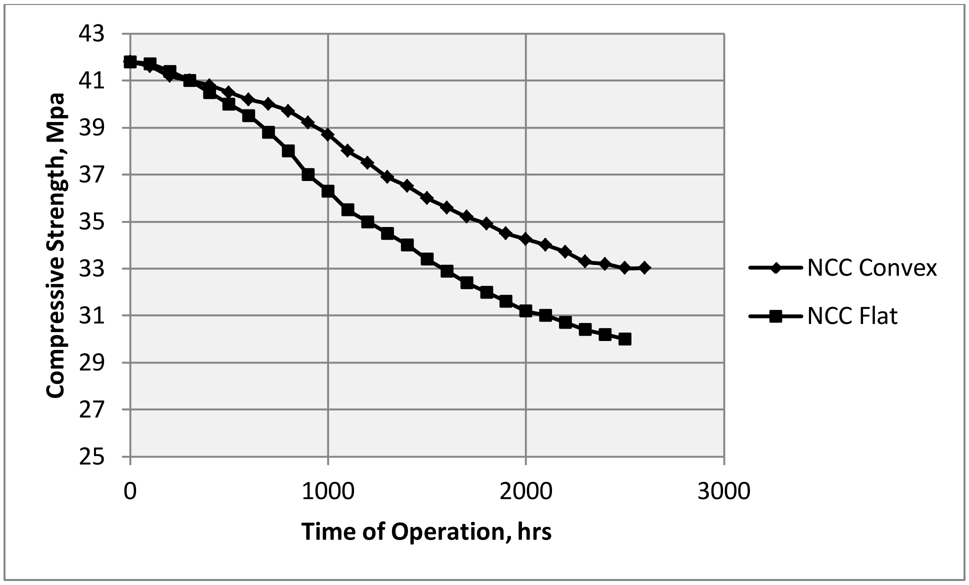

Fig.(13) Compressive Strength of Quaking Loads versus Operation Time of the Flat and Convex Concrete Models for NCC Mixes

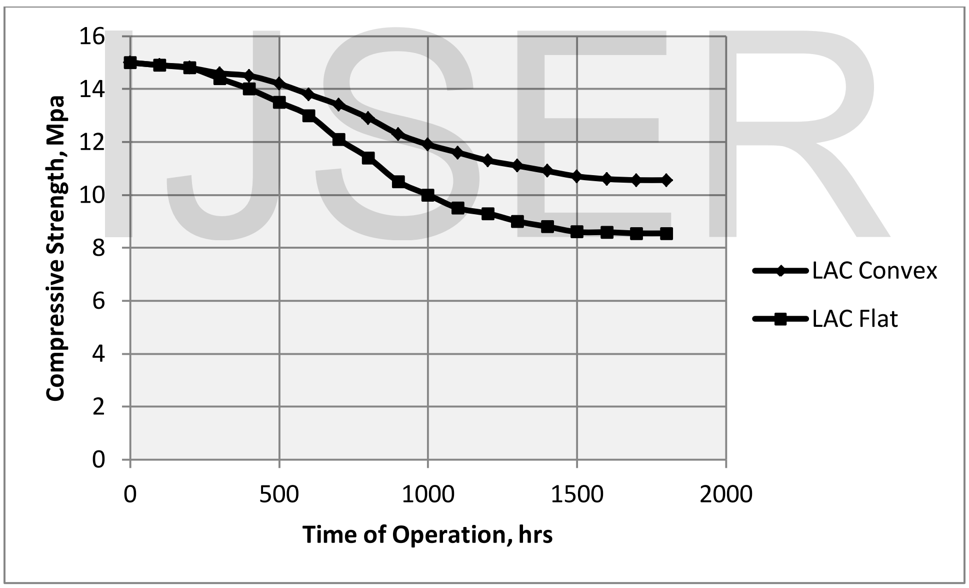

Fig.(14) Compressive Strength versus of Quaking Loads Operation Time of the Flat and Convex Concrete Models for LAC Mixes

Results Discussion

1- The flat and convex concrete models get their compressive strength of (57.27 Mpa, 41.8 Mpa, and 15Mpa) after 90 days of curing for SCC, NCC, and LAC mixes respectively.
2- The flat concrete models lose 33.29%, 68.91%, 66.66% of their compressive strength under the effect of the repeated impact loads with energy of 40KJ, 14KJ, and 10KJ for SCC, NCC, and LAC mixes respectively as represented in Fig.(6). The foregoing results indicate that although the flat concrete models made of SCC exposed to the maximum repeated impact loads of 40KJ, they lose a minimum percentage of its compressive strength of 33.29%.

3- The convex concrete models lose 33.26%, 56.93%, 46.66% of their compressive strength under the effect of the repeated impact loads with energy of 44KJ, 18KJ, and 11KJ for SCC, NCC, and LAC mixes respectively as represented in Fig.(7). The foregoing results indicate that although the convex concrete models lose a less percentage of its compressive strength although they endure to more energy.
4- The flat concrete models lose 10.1%, 28.2%, 43% of their compressive strength under the effect of the quaking loads with operation time of 4300hrs, 2500hrs, and 1700hrs for SCC, NCC, and LAC mixes respectively as represented in Fig.(11). The foregoing results indicate that although the flat concrete models made of SCC exposed to the maximum period of operation time of 4300hrs, they lose a minimum percentage of its compressive strength of 10.1%.
5- The covex concrete models lose 6%, 21%, 29.6% of their compressive strength under the effect of the quaking loads with operation time of 4300hrs, 2500hrs, and 1700hrs for SCC, NCC, and LAC mixes respectively as represented in Fig.(12). The foregoing results indicate that although the convex concrete models made of SCC exposed to the maximum period of operation time of 4300hrs, they lose a minimum percentage of its compressive strength of 6%.

Conclusions

1- The current study indicates that the concrete members made of self-compacting concrete (SCC) mixes possess the maximum mechanical performance and resistivity to concrete deterioration due to the effect of various type of loadings comparing with respect to the conventional concrete mixes (NCC) and the light aggregate concrete (LAC) mixes.
2- It is concluded that the convex concrete members offer more resistance to dynamic loads than flat concrete member.

Recommendation

It is recommended to use the SCC mixes for members where and when a high mechanical performance is required.

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