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Evaluation of Fatigue Parameters in Low-Strength Concrete by Replacement of Natural Sand

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ABSTRACT

The study provides a general overview on plain cement concrete subjected to repetitive loads. The concrete specimens are subjected to low amplitude and high-frequency cyclic loads. The fatigue performance of plain concrete with fine aggregates as natural sand is compared with the substitutes of natural sand such as m-sand (manufactured sand) and slag sand. A cost comparison is also carried out to understand the economy.

Key words: *Fatigue, Concrete, Non-structural members, Nominal mix.*

1. INTRODUCTION

Some of the non-structural members, such as the entry and exit of the bridge, entry of parking platforms in residential, official, and public buildings, do also undergo repetitive loads, these non-structural members will be neglected and designed superficially which will lead to early failure and further results in the structural failure which may lead to uneconomical construction, so keeping in view of the above consequence to overcome such issues a study is made to understand the fatigue behavior of low/nominal strength concrete by adding substitutes for fine aggregates [1-3]. Fatigue in a material occurs when they are subjected rapidly fluctuating and cyclic stresses. In general, failure of material occurs due to fatigue at stress levels much lower than the yield strength of the material for static load. Under cyclic loadings, cracks can grow whenever they are discontinuous/flaws. Fatigue parameters are considered during the design of rigid pavement (such as bridges and car parking platforms in residential and public buildings), which can be stated as main members. However, places, such as the entry and exit of bridges and the entry of parking platforms, tend to fail due to repetitive loads. Hence, fatigue parameters of these non-structural members should be considered. This scenario or failure occurs due to negligence and superficial design, which leads to early failure and will have a direct impact over main members. There are two types of fatigue loading that can result in different failure characteristics, which can be classified as low cycle fatigue and high cycle fatigue; this study deals with low fatigue cycle, wherein the amplitude is low and frequency is high.

2. METHODOLOGY

The common method of fatigue testing is via flexural tests. In our experiment, the specimen of beam of size (500×100×100) mm is used. Figure 1 shows the test setup for a concrete beam specimen subjected to flexural fatigue load. The beam is loaded at two points, keeping the end conditions/constraints as simple supports; the applied load is the cyclic sinusoidal type. The deflections of each cycle are measured by load variable differential transformer placed on the beam at center. The recorded data are accumulated in the computer. The ratio of minimum stress to maximum stress in one cycle of loading in a fatigue test is constantly maintained at 0.75.

Based on the characteristic compressive strength (3, 7, and 28 days), the loads are calculated for the constant stress ratio value, i.e., for 0.75, and the same load is applied over two points on the beam specimens, respectively.

3. RESULTS AND DISCUSSION

Table 1 shows the fatigue life cycle of concrete beam with different types of fine aggregates (natural sand, slag, M-sand) practically tested for 3, 7 and 28 days of curing and as per IRC 58-2002 recommendation. Figure 3 shows the comparisons of fatigue cycles for

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Table 1: Comparison of fatigue cycle of concrete beam and load bearing capacity as per IRC 58-2002 recommendations versus the practically attained data.

Serial number	Specimen	Number of days of curing	Fatigue cycles as per IRC 58-2002		Fatigue cycles attained practically	
			Peak load in kg	Number of cycles/ Fatigue life	Peak load in kg	Number of cycles/ Fatigue life
1	Concrete beam with fine aggregate as natural sand	3	558	477	579	505
		7	673	477	676	1160
		28	764	477	762	720
2	Concrete beam with fine aggregate as m-sand	3	533	477	538	957
		7	658	477	683	635
		28	885	477	845	1065
3	Concrete beam with fine aggregate as slag	3	584	477	589	340
		7	696	477	697	600
		28	824	477	870	425

Table 2: Cost analysis of concrete specimens with natural sand, slag sand, and m-sand as fine aggregates.

Serial number	Specimen	Number of mold	Quantity	Rate per cubic meter	Amount in rupees
1	Concrete beam with fine aggregate as natural sand	9 cubes*	0.03038	56328.1	1710.96
		9 beams#	0.045		2534.76
2	Concrete beam with fine aggregate as slag	9 cubes*	0.03038	41327.5	1255.32
		9 beams#	0.045		1859.73
3	Concrete beam with fine aggregate as m-sand	9 cubes*	0.03038	46118.2	1400.84
		9 beams#	0.045		2075.32

*Cubes of size 150×150×150 mm. #Beams of size 500×100×100 mm

Figure 1: Test setup for fatigue testing of concrete beam specimen.

Figure 2: Apparatus for flexural fatigue testing of concrete beam.

the concrete beams casted with different types of fine aggregates (natural sand, slag, M-sand) tested for 3, 7 and 28 days of curing. The fatigue cycles of concrete beam specimen with M-sand as fine aggregate for 28 days of curing is found to be better. Figure 2 shows the fatigue testing machine arrangement which is used to apply fatigue load on various specimens.

Table 2 shows the Cost analysis of concrete specimens with natural sand, slag sand and M-sand as fine aggregate. Figure 4 shows the comparison of cost per cubic meter of concrete for different types of fine aggregates (natural sand, slag sand, M-sand). The concrete beam with slag as fine aggregate is cost effective.

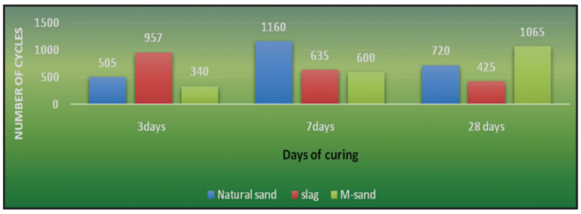

Figure 3: Comparisons of fatigue cycles for the concrete beams casted with different types of fine aggregates (natural sand, slag sand, m-sand) tested post 3, 7, and 28 days of curing.

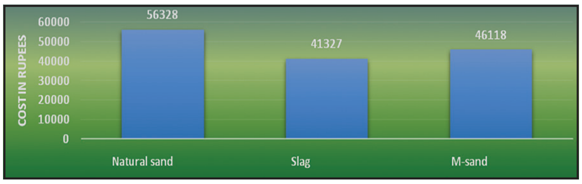

Figure 4: Cost evaluation per cubic meter of concrete for three different types of fine aggregates (natural sand, slag sand, m-sand).

4. CONCLUSION

Based on the results obtained, the following conclusions can be drawn:

Post flexural fatigue test on concrete beams; it can be concluded that the beams with natural sand, slag sand, and m-sand as fine aggregates proved to have better load bearing capacity and fatigue cycle results compared to IRC 58-2002 recommendations.

It can also be claimed through the test results that the concrete beams casted using m-sand as fine aggregates displayed better load bearing capacity as well as higher fatigue cycles compared to beams with fine aggregates as natural sand and slag sand.

Concrete beams casted using natural sand as fine aggregates proved better than slag sand, however, a little inferior to m-sand in terms of load bearing capacity as well as number of fatigue cycles.

However, concrete beams with slag sand as fine aggregates demonstrated that it is inferior compared to beams casted using m-sand and natural sand as fine aggregates.

However, post cost evaluation of materials, the concrete beams with slag sand as fine aggregates proved to be most reasonably priced, beams with m-sand as fine aggregates were slightly costlier but beams with natural sand as fine aggregates were the priciest.

In the present day scenario, accessibility to natural sand has turned out to be tiresome and also it is becoming scarce, hence slag sand as well as m-sand can be used as alternatives and also cost effective replacement for the of natural sand, especially in nominal type of mix used in non-structural members subjected to high frequency and low amplitude type of fatigue loading.

5. REFERENCES

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***Bibliographical Sketch**

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