Experimental Investigation on Compressive Strength of Concrete after Early Loading

Shaik Johny Ibrahim, Y V Subba Reddy

Abstract— **In modern construction projects, it is necessary to work with concrete before its strength can be fully developed. Loading is often the most intensive stage of structure's life. With the concrete, its early stages of strength development are essential to ensure the better performance of structure. In this present study, experiment is carried out to stimulate high construction loading at initial ages to better understand the effect of early loading and changes in ultimate strength at later ages. In this study, we are evaluating the results for replaced cement concrete mixes. So Cement is replaced with Quarry rock dust with 23% QD to the weight of cement and Steel fibers of size 0.6 mm were added to the total volume of concrete. The results from this study indicate the 28 days strength of wet cured concrete cubes increased considerably when specimens are loaded up to 95% of their Ultimate Strength at 1, 3 and 7 days after casting.**

Index Terms—**Early loading, Compressive strength, Quarry rock dust, Steel fibers.**

I. Introduction

Structures with concrete are built to withstand a variety of loads and may be exposed to many different environments such as exposure to seawater, sulphated-bearing soils, cyclic wetting, salts, abrasion and drying. The materials and proportions used to produce concrete will depend on the loads required to carry and the environment to which it will be exposed. Properly planned designed buildings structures are strong and durable throughout their service of life

After completion of proper proportioning, mixing, batching, consolidation, finishing and curing concrete hardens into a non-combustible, durable, abrasion resistant, and watertight building material that require little or no maintenance. Furthermore, concrete is an excellent building material because it can be formed into wide variety of colors, shapes and textures for use in an unlimited number of applications.

Loading in construction is often in the most intensive stages of structure life, with the concrete still in its early ages of strength development it is essential to ensure it is not overloaded. Premature removal of formwork, moving or lifting of precast concrete or large construction live loads can cause cracking or other damage. Even if a structure does not collapse during the construction stage, it is possible to damage it and reduce strength. The aim of this project was to determine the effects of compressive strength of concrete at stages typical in the use of shoring/ reshoring technique, widely used in concrete floor construction in multi-storey buildings, where concrete can undergo large compressive strength soon after casting.

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II. LITERATURE REVIEW

Christopher Dean (2012) made an experimental study on early load effect on compressive strength. Now a day's construction loadings are applied before its construction so that he made an attempt to study the early age loading effect on its strength. He tested for 70% -90% of ultimate compressive strength at 1, 3 and 7 days and re tested all samples at 28 days. He concluded from his studies, i). Loading specimen to failure at early age shows less strength at 28 days ii). Loading 70% - 90% of their ultimate strength for 1 and 7 days exhibited an increase in strength 28 days of casting.

Soman.K (2014) conducted some experiments on replacement of cement with the quarry dust sludge of 2.5 % to 20 % and reported that there is no significant change with the 7.5% replacement with cement in compressive strength, split tensile and flexural strength. His studies so far reveals that quarry dust as cement replacement material up to 5% to 10% increase its durability without compromising strength and workability. He also concluded that replacement of Quarry dust with cement reduces carbon emissions and made for green buildings nowadays and also quarry dust as land filling material both used for environmental as well as economical.

Another interesting investigation was carried out by **Shreyas Y S, Sharath N (2015)** about the trail study made by absolutely supplanting quarry dust and recycled aggregates are used in fiber reinforced concrete. 0.2 % - 0.4 % of polypropylene and polyester are used in M30 mix and strength tests are carried out 7 ,14 and 28 days . He concluded from his investigation, by polypropylene fiber 1.5% by its volume of concrete of M30 flexural strength is more than conational concrete. Fiber reinforced concrete has preferably more compressive and Flexural strength when using polypropylene.

Utilization of recycled fibers from postconsumer and industrial waste offer more benefits for land filling and low cost materials and as waste reduction and resource conservation. Carpets are one of the major components around the world 1-2% 0f all solid waste materials by its volume. From carpets nylon and polypropylene fibers are made and used as enchaining material in concrete. **H. Mohammad Hosseini, A.S.M. Abdul Awal (2013)** conducts tests on sample and evaluates the test result of the compressive strength, split tensile strength and flexural strength with 0.5%- 2% fibers are additionally added for better results. He concluded that, density and workability are reduced with fiber content volume. Flexural and split tensile strength are increased with fiber volume but compressive strength is reduced little compared with conventional one. Crack formation will also be small with these fiber content.

Abdul Ghaffar, Amit S. Chavhan (2014) conducted study on steel fibers to enhance the mechanical properties o concrete. He made a comparison between convention concrete to fiber reinforced concrete. He considered 0% to 5% of fibers with the 0.5 % intervals by its weight of cement. He tested the hooked steel fibers for their mechanical properties. He concluded that i). by increasing fiber content the workability decreases. ii). Wet density decreases with increase of percentage of fiber volume iii). At 3% and 4% the compressive strength and flexural strength maximum iv). Ductility of concrete is increased with increase of fiber content.

Fibers are generally used to enhance mechanical properties, resistance to cracking and Strengthening of concrete **Aiswarya Sukumar (2014)** made an attempt to use fibers for increasing strength .He made a comparison among the steel, glass and polypropylene fibers for compressive and flexural strength. He conducted different samples with various fiber volume fractions and reported the results. Results represent with the presence of steel fibers the compressive strength, flexural and split tensile strength has greater values. Crack formation is also small with the steel fibers gives good results. Addition of steel fibers in concrete not only gives the strength characteristics and but also ductility is more. This technology provides to eliminate the steel bars in conventional concrete if the fibers must distribute and oriented in specific manner, which is difficult. He also suggested that the fibers can be used in case of steel bars reinforcement of construction work is eliminated hence the cost of construction significantly reduced.

Lidia Rizzuti and Francesco Bencardino (2014) critically examined specimens with fiber volume fraction of 1%, 1.6%, 3% and 5%. He investigated on peak load, post – peak behavior and its residual strength. The effect of steel fiber volume fraction on strength, ultimate stain and ductility index are highlighted from his studies. The post peak behavior is improved with the increase in volume of fibers. At 1.6% and 3% fiber volume, the ultimate strain at failure has three to five times the ultimate strain value. The medium high steel fiber content significantly improves the post peak behavior and reduces negative slope by extending softening branch.

Ankit Agrawal, Tarit Jain, Sarang Agarwal (2014) done an experiment with steel reinforces fibers with the alternative material of blast furnace slag with Cement based on different curing methods such as normal curing, steam curing and hot air oven curing with addition of HRWR super plasticizer for combination method is evaluated. The results concluded that 50% slag replacement with cement shows maximum compressive strength according to cuing methods. This can be concluded that the slag gives higher value by accelerated curing along with different dosage of steel fibers.

E. Mello, C. Ribellato, E. Mohamedelhassan (2014) investigates in the improvement in concrete with cellulose, steel, carbon and PET fibers of each with 4% to the fresh concrete and 28 days of curing is allowed and tested for compressive strength, flexural strength and split tensile strength. Results concluded that addition of cellulose decreases compressive strength between 9.8% to 16.4% but acceptable. Addition of steel fibers increase up to 20% of its compressive strength nut it show very good performance under the tensile and flexural strength. Carbon also gives good result in all tests but with PET fibers it gives very poor results in strength. In cost wise only steel and carbon fibers justifies the extra cost than others.

Seong-Cheol Lee (2015) investigate the compressive behavior of the fiber reinforced concrete with end hook steel fibers through unaxial compressive test in which the fiber volumetric ratio and fiber aspect ratio. The result exhibits the ductile nature and the strain in compressive strength increases along with fiber volume content. It clearly shows the steel fibers are best material to overcome the crack and shrinkage and best ductility character. He further advised to investigate results with all other types of fibers.

Laterite is abundant in nature which is suitable to replace with fine aggregate and don't require any washing or it doesn't react with during hydration. Tensile strength of concrete is improved with the randomly aligned discontinuous steel fibers. **Madhu TK (2016)** made an experimental attempt with Laterite and 0% to 2% fibers with 0.5% interval of volume of fibers content with concrete is used. Specimen is tested for flexural strength and split tensile strength containing fibers in concrete. Results are represented in graphically of aspect ratio vs. both flexural and split tensile strength.

Steel fibers are mainly used for secondary reinforcement which controls the crack and shrinkage to increase the toughness of concrete. **Tarun Gehlot, Divanshu Seervi (2017)** studied the compressive strength of concrete with addition of the steel fibers with 0.5% interval from 0% to 2% of M20 concrete. The results concluded that the strength of steel fibers increases linearly with addition of quantity of fibers to the concrete. High percentage of fibers added to the concrete causes segregation and hardness to the concrete which greatly reduces the concrete. Optimum 1.5% steel fibers addition gives best results after that the strength was reduced.

III. Methodology

Cement is replaced with quarry dust with 23% of QD to the weight of cement and steel fibers of size 0.6 mm were added to the total volume of concrete. The results from this study indicate the 28 days strength of wet cured concrete cubes increased considerably when specimens are loaded up to 95% of their ultimate strength at 1,3 and 7 days after casting. This phenomenon of increased strength after loading and subsequent curing has been reported in the literature for many years, but use of modern compressive loading equipments has enabled to show the final strength has a high level of correlation with the displacement during the initial stages of early loading. In the present study are to simulate high construction loading at initial ages to better understand the effect of early loading and the changes in ultimate strength at later ages.

In this study, 150 mm concrete cubes were compressed to loads of 10 to 95% of their ultimate strength to simulate early overloading at 1,3, and 7 days after casting of cubes, which is typical of early stages in construction of concrete structures. These specimens are reloaded at 28 days after being wet cured under laboratory conditions. Comparing the results from early loaded specimens and controlled specimen an increase in strength was recorded for most although not all specimens.

IV. Test Procedure

A. Test specimen:

Test specimens of size 150mm cubes were prepared for testing the compressive strength of concrete. The concrete mixes with varying percentages of quarry dust as 23% partial replacement of cement were cast.

B. Mixing & Casting of Specimen:

In this study, to make concrete, cement and fine aggregate were first mixed dry to uniform colour and then coarse aggregate was added and mixed with the mixture of cement and fine aggregates. Water is then added and the whole mass is mixed. The interior surface of the moulds and the base plate were oiled before concrete was placed. After 24 hours the specimens were removed from the moulds and placed in clean fresh water at a temperature of 27° ± 20°C.

C. Curing:

The test specimens are stored in moist air for 24 hours and after this period the specimens are marked and removed from the moulds and kept submerged in clear fresh water until taken prior to test.

D. Testing:

The specimens 150 mm x 150 mm x 150mm were casted and tested after 7 and 28 days of curing measured from the time water is added to the dry mix. For testing in compression, no cushioning material was placed between the specimen and the plates of the machine. The load was applied axially without shock till the specimen was crushed.

V. Results and Discussion

Table 1. Compressive strength of nominal concrete mix

% of Loading	After 1 day early loading	After 3 days early loading	After 7 days early loading	28 days compressive strength
10	44.88	44.66	48.22	49.11
20	49.33	46.44	50	49.55
30	44.88	**52.44**	47.11	43.11
40	48.88	45.55	50.22	50.44
50	38.66	35.77	41.33	39.77
60	42.22	36	37.55	36
70	35.77	31.33	33.77	39.33
80	36.66	36.33	36.66	40.22
90	22.66	42.88	33.33	39.33
95	34	26.66	39.11	40

Table 2. compressive strength of with 23% replacement of concrete mix

%of Loading	After 1day early loading	After 3days early loading	After 7days early loading	28days compressive strength
10	43.33	42.44	44.55	46.55
20	47.99	53.4	47.33	48
30	46.88	48.33	47.94	42.44
40	45.77	**54.66**	52.44	49.33
50	39.33	36.44	39.11	52.34
60	43.44	34.22	49.33	38.44
70	37.9	35.9	36.43	36.55
80	35.55	38.44	37.44	41.33
90	37.55	34.66	32.33	35.55
95	34	24.55	22.4	36

Table.3 compressive strength of with steel fiber reinforced concrete mix

% of Loading	After 1 day early loading	After 3days early loading	After 7days early loading	28days compressive strength
10	37.33	43.55	39.77	45.66
20	39.55	40	42.44	41.94
30	47.94	45.44	**52.33**	46.75
40	42.44	50.94	36.94	39.33
50	36.44	37.33	40.14	37.49
60	37.44	43.44	42.44	49.55
70	37.9	42.14	45.33	48.66
80	46.88	39.33	46.53	45.99
90	35.44	31.9	35.77	43.99
95	34.66	27.44	32.76	45.94

A. Comparison for 10% Early Loading

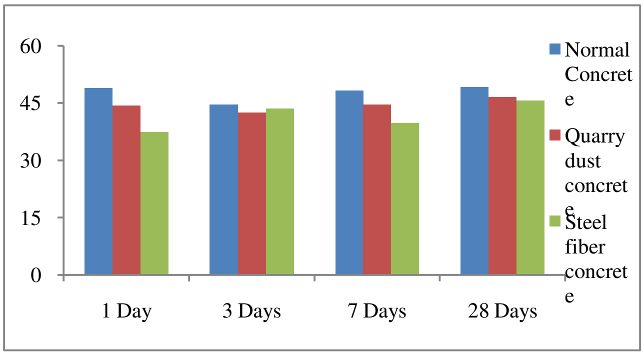

Fig.1 10% Early Loading

B. Comparison for 20% Early Loading

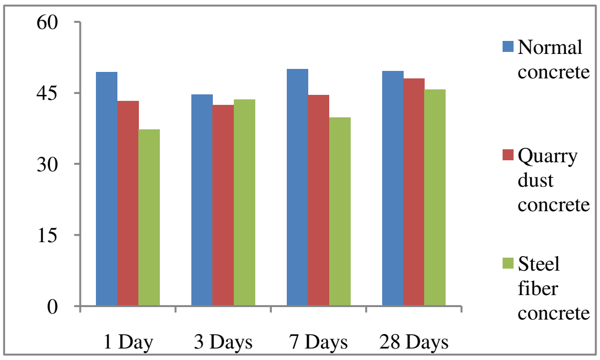

Fig.2 20% Early Loading

C. Comparison for 30% Early Loading

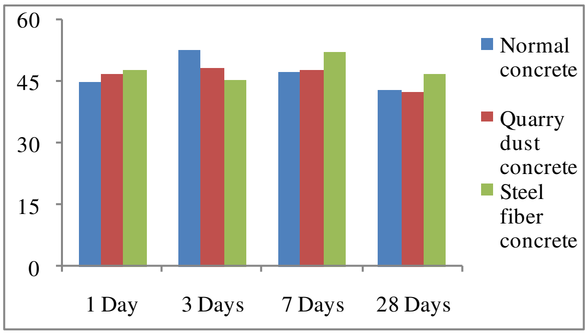

Fig.3 30% Early Loading

D. Comparison for 40% Early Loading

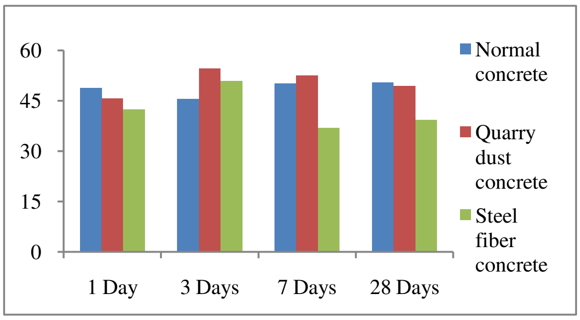

Fig.4 40% Early Loading

E. Comparison for 50% Early Loading

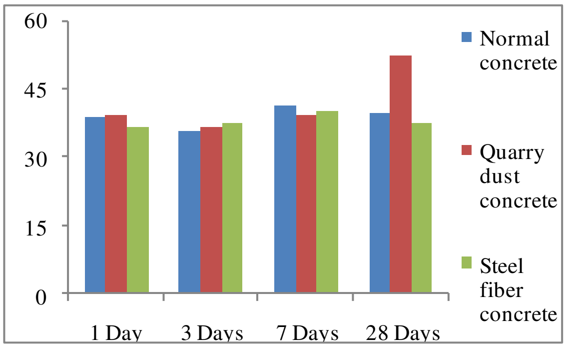

Fig.5 50% Early Loading

F. Comparison for 60% Early Loading

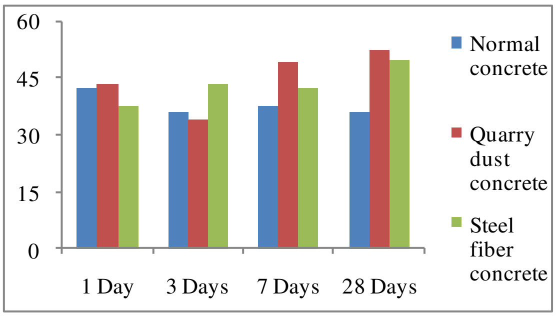

Fig.6 60% Early Loading

G. Comparison for 70% Early Loading

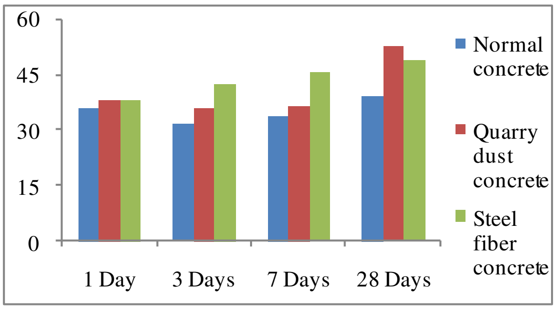

Fig.7 70% Early Loading

H. Comparison for 80% Early Loading

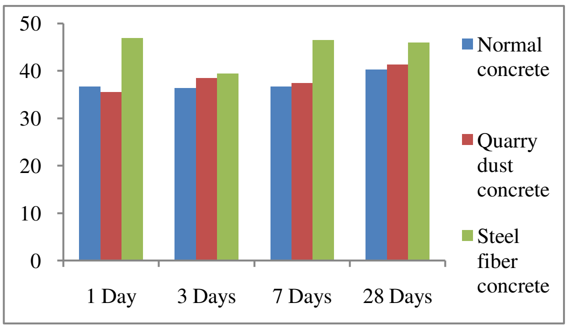

Fig.8 80% Early Loading

I. Comparison for 90% Early Loading

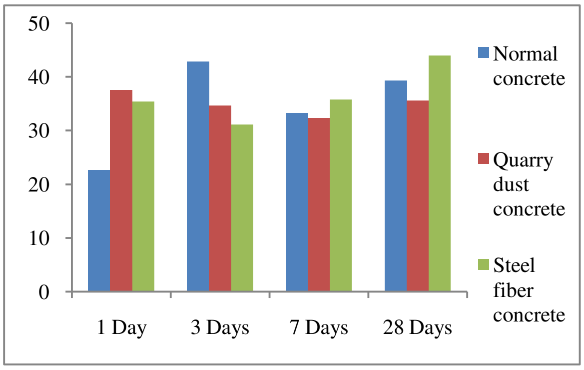

Fig.9 90% Early Loading

J. Comparison for 95% Early Loading

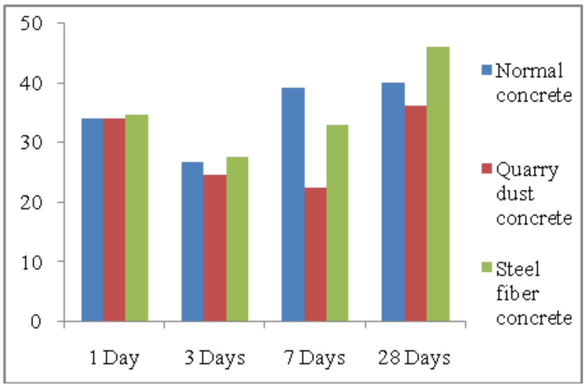

Fig.10 95% Early Loading

VI. CONCLUSION

Based on the experimental investigation the following conclusions have been drawn.

- Loading specimens to failure at early ages reduces the strength at 28 days.
- The reduction in strength of specimens is dependent upon the extent to which the specimen has been loaded.
- Specimens loaded between 10 and 95% of their ultimate load between 1 day and 7 days exhibited an increase in strength at 28 days after casting.
- Cubes casted with partial replacement of cement with quarry dust gives higher values than the cubes casted with control mix and the mix with steel fibers.
- At 10% of loading, Maximum compressive strength for the age of the concrete is 28 days for normal mix
- At 20% of loading, Maximum compressive strength for the age of the concrete is 7 days for normal mix
- At 30% of loading, Maximum compressive strength for the age of the concrete is 3 days for steel reinforced fiber concrete.
- At 40% of loading, Maximum compressive strength for the age of the concrete is 3 days for quarry dust concrete.
- At 50% of loading, Maximum compressive strength for the age of the concrete is 28 days for quarry dust concrete.
- At 60% of loading, Maximum compressive strength for the age of the concrete is 28 days for quarry dust concrete.
- At 70% of loading, Maximum compressive strength for the age of the concrete is 28 days for quarry dust concrete.
- At 80% of loading, Maximum compressive strength for the age of the concrete is 1day for steel fiber reinforced concrete.

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