

Experimental Investigation on Partial Replacement of Fine Aggregate with M-Sand in Pretensioned Concrete Beam

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ABSTRACT: Recent developments of high performance concrete, increasing amounts of prestressing, and increasing use of deep girders have resulted in increasing popularity of precast pretensioned concrete girders in bridge construction. These developments have increasingly contributed to end zone cracking. Natural or River sand are weathered particles from rocks which are of various shapes and sizes depending upon the weathering action of rivers. In the present scenario, natural sand with required properties is not easily/locally available. In most of the situations, the natural sand is being brought from faraway places to the construction site. Such type of transporting the river sand from faraway places will increase the construction costs. Also these natural river sand is also becoming unavailable due to many reasons. Hence it is very essential to find an alternate material that can substitute the natural river sand either partially or fully. In Tamil Nadu, stone quarries are found in abundance and are wide spread across the state. They are the good source for the coarse aggregate and manufactured fine aggregate. There is a need to make use of the stockpiles of quarry fines generated in those crushers. Hence to make use of these M-sand in the construction industry, a systematic study has to be carried out on the replacement with Natural River sand in making concrete. Experimental investigations carried out on the evaluation of properties of M-sand obtained from different locations (sources) is presented in this paper. Based on the experimental results, mix design for different grades of concrete was carried out using M-sand obtained from two sources by replacement of natural sand. Experimental studies carried out on the properties of fresh and hardened concrete made using the developed mix proportions is also presented in this paper. It was reported that 50% replacement of fine aggregate by M-sand gave better strength and durability aspects than the conventional concrete. From the reported literature it can be seen that quarry fines are more suitable for replacement of natural river sand

KEYWORDS: FINE aggregate, Coarse aggregate, pre-tensioned concrete, M-Sand.

I. INTRODUCTION

In the recent years, the Indian construction and infrastructure industry has seen rapid development. The main natural raw material used by the construction industry is natural river sand as fine aggregate in concrete. Construction diligence with sustainability is of great importance. Sustainability is a broad term describing a desire to carry out activities without depleting resources without compromising the ability of future generations to meet their own needs. The term sustainable development can be described as enhancing quality of life and to improve social, economic and environmental conditions for present and future generations. Natural or River sand are weathered particles from rocks which are of various shapes and sizes depending upon the weathering action of rivers. In the present scenario, natural sand with required properties is not easily/locally available. In most of the situations, the natural sand is being brought from faraway places to the construction site. Such type of transporting the river sand from faraway places will increase the construction costs. Also these natural river sand is also becoming unavailable due to many reasons. Hence it is very essential to find an alternate material that can substitute the natural river sand either partially or fully. Longitudinal web cracks have been observed during prestress transfer, in the ends of precast pre-tensioned concrete I-girders. The cracks are most visible at the time of lifting girder from the prestressing bed, shortly after prestress release. End zone cracks

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have also been observed in other girder shapes, such as box girders, voided slabs and tee beams. With the increasing use of high strength concrete, deep girders, thin webs and high prestress forces, these cracks are becoming more prevalent and, in some cases, larger. The current AASHTO LRFD provisions for end zone reinforcement were developed for lower concrete strength and prestress levels than current practice.

II. MATERIALS AND METHODS

Cement:

Cement is a binder that sets and hardens and can bind other materials together. Ordinary Portland Cement (OPC) 53 grade is used. The most common cement is used is ordinary Portland cement. Out of the total production, ordinary Portland cement accounts for about 80 to 90 percent.

Fine aggregate:

The sand particles should also pack to give minimum void ratio, higher voids content leads to requirement of more mixing water. In the present study the sand conforms to zone II as per the Indian standards. The fine aggregate belongs to grading zone II.

Coarse aggregate:

Angular shape aggregate which passes through 20 mm sieve and retain on 10mm are used as coarse aggregate in this project work. The coarse aggregate is having dust particles and so it could be cleaned well by washing and removing the dust particles. The sieve analysis of fine and coarse aggregates is confirmed to IS10262

MANUFACTURED SAND

The fine aggregates or sand used is usually obtained from natural sources specially river beds or river banks. Now-a-days due to constant sand mining the natural sand is depleting at an alarming rate. Sand dragging from river beds has led to several environmental issues. Due to various environmental issues Government has banned the dragging of sand from rivers. This has led to a scarcity and significant increase in the cost of natural sand. There is an urgent need to find an alternative to river sand. The only long term replacement for sand is manufactured sand. The cheapest and easiest alternative to natural sand is manufacturing sand by crushing rocks/stones in desired size and grade by suitable method. Sand produced by such means is known as manufactured/ crusher/artificial sand

STAGES OF PRE-TENSIONING

In pre-tensioning system, the high-strength steel tendons are pulled between two end abutments (also called bulkheads) prior to the casting of concrete. The abutments are fixed at the ends of a prestressing bed.

Once the concrete attains the desired strength for prestressing, the tendons are cut loose from the abutments.

The various stages of the pre-tensioning operation are summarised as follows.

- 1) Anchoring of tendons against the end abutments
- 2) Placing of jacks
- 3) Applying tension to the tendons
- 4) Casting of concrete
- 5) Cutting of the tendons.

DEVICES

The essential devices for pre-tensioning are as follows.

- Prestressing bed
- End abutments
- Shuttering / mould
 - Jack
- Anchoring device
- Harping device (optional)

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PRESTRESSING BED, END ABUTMENTS AND MOULD

An extension of the previous system is the Hoyer system. This system is generally used for mass production. The end abutments are kept sufficient distance apart, and several members are cast in a single line. The shuttering is provided at the sides and between the members. This system is also called the Long Line Method.

The end abutments have to be sufficiently stiff and have good foundations. This is usually an expensive proposition, particularly when large prestressing forces are required. The necessity of stiff and strong foundation can be bypassed by a simpler solution which can also be a cheaper option. It is possible to avoid transmitting the heavy loads to foundations, by adopting self-equilibrating systems. This is a common solution in load-testing. Typically, this is done by means of a 'tension frame'.

JACKS

The jacks are used to apply tension to the tendons. Hydraulic jacks are commonly used. These jacks work on oil pressure generated by a pump. The principle behind the design of jacks is Pascal's law. The load applied by a jack is measured by the pressure reading from a gauge attached to the oil inflow or by a separate load cell. The following figure shows a double acting hydraulic jack with a load cell

ANCHORING DEVICES

Anchoring devices are often made on the wedge and friction principle. In pre-tensioned members, the tendons are to be held in tension during the casting and hardening of concrete. Here simple and cheap quick-release grips are generally adopted. The following figure provides some examples of anchoring devices

Mix design:

The mix design of M35 grade concrete is calculated using IS 456-2000 and IS 10262-2009. The material required as per design are given in Table: 1

Materials	W/C ratio	Cement	Fine aggregate	Coarse aggregate
Ratio	0.45	1	1.5	2.84

TABLE: 1 Material required as per is method of design

SPECIMEN DETAILS:

The following table shows the details of the specimens prepared for casting process.

S.NO	SPECIMENS	M Sand replacement %	TOTAL NO
1	CONTROL BEAM	0%	3no
2	POSTTENSION CONCRETE BEAM	50%	3no

TABLE: 2specimen details

III. FLEXURAL STRENGTH FOR RCC BEAM

All beams (100mm x 150mm in cross section and 1600mm in length) were tested as simply supported beams under three point loading over an effective span of 1400mm. The load shall be applied at a rate of loading of 400kg/min for the 15 cm specimens and at a rate of 180kg/min for the 10cm specimens. The loads were applied at a distance of 533mm on either side of the mid span of the beams of 1600mm length. The loads were monitored through a high accuracy load cell with a load sensitive of 0.1 tonnes. For this case, mid span deflection was measured using dial

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gauges of least count 0.01mm. The parameters such as initial cracking load, ultimate load and the deflected shape of the specimens were noted.

Determine the modulus of rupture ($F_b = 3PL / 2bd^2$)

Where

p = maximum load

L = span of the specimen in mm

b = breath of the specimen

d = depth of the specimen.

IV. EXPERIMENTAL RESULTS

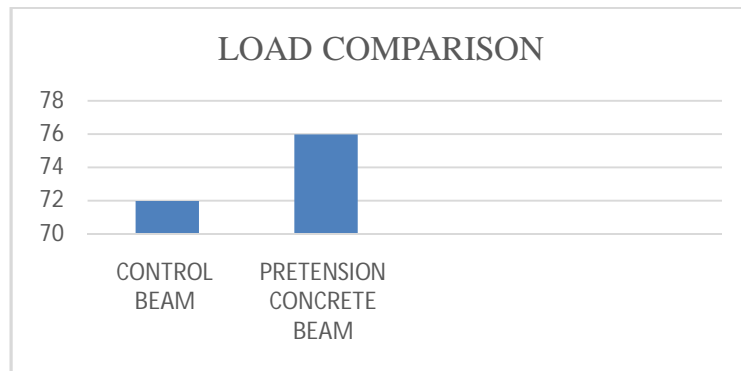
The following table shows the details of the flexural strength specimens.

S.NO	SPECIMEN	LOAD (kN)	FLEXURAL STRENGTH(N/mm ²)
1	Control beam	72	47.29
2	Post-tension concrete beam	76	49.77

TABLE3 FLEXURAL STRENGTH

LOAD COMPARISON:

The following graph table shows the details of the load comparison for specimens.



LOAD COMPARISON

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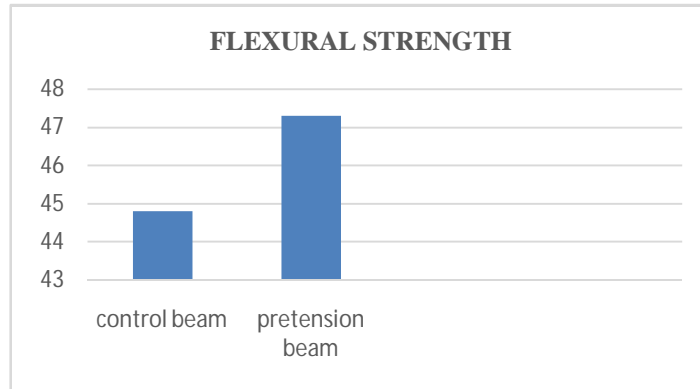
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FLEXURAL STRENGTH:

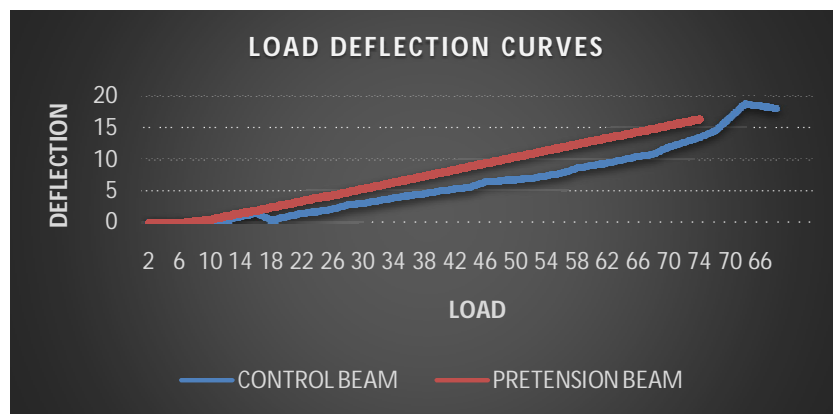
The following graph shows the details of flexural strength of specimens.



FLEXURAL STRENGTH

LOAD DEFLECTION CURVE

The following graph shows the details of load deflection of specimens



LOAD DEFLECTION CURVE



(a)



(b)



(c)

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Fig. 2. Preparation of specimen (a) travelling pre-tensioning stress bench (b) a double acting hydraulic jack with a load cell (c) anchoring (d) pouring of concrete (e) steam curing chamber



Fig. 3 Testing of specimen (a) specimen ready for test (b) specimen ready for test

V. CONCLUSION

The performance was observed and discussed in terms of failure modes, load Vs deflect and load carrying capacity. Based on the test report on the, the following conclusions can be made:

- Concrete acquires maximum increase in compressive strength at 50 % sand replacement.
- Split tensile strength is maximum at 50 % replacement of natural sand by M sand.
- Maximum flexural strength is also at 50 % replacement. The percentage of increase compared with control concrete is 20%. Whereas the flexural strength is 47.29N/mm².
- The derivation gives clear picture that M sand can be utilized in concrete mixture as a quality substitute instead of river sand to a high strength at 50% replacement.

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