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Tensile behavior of reactive powder concrete containing steel fibres and silica fume

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Abstract:—Concrete is very much weak in tension but by addition of randomly oriented short corrugated steel fibres will change the behavior from brittle to ductile and hence forth a precise evaluation of tensile behavior of RPC especially uni-axial tensile is required. The present investigation shows a behavior of RPC in direct tension using modified dog bone test .RPC in the initial portion shows a linear relation for a short time and qualitatively shows very gentle slope linear relation indication less value of modulus of Elasticity. Strength obtain using cylinder splitting tensile strength gives higher tensile strength.

Keywords:—RPC, Tensile Strength, MDB Specimen, splitting tensile.

I. INTRODUCTION

Brittle matrices such as concrete and plain mortar lose their tensile load carrying capacity almost immediately after formation of the first crack, addition of lower fibre content in ordinary concrete does not help in enhancing the tensile strength beyond first cracking. FRC is therefore considered to be a quassi-brittle material with tension softening deformation behavior. In case of ordinary concrete and FRC of lower volume fraction, tensile characteristic are not important. In the Design procedures of concrete structure and thus standardization of tensile test and evaluation method is not a necessary.

The proper characterization of the post cracking behavior is represented in terms of tensile stress -strain relationship, since such specimen do not unload after cracking, but strain hardens due to which micro cracks appear as an elastic damage spread over a volume of material, Uniaxial tensile test though simple in concept it is difficult to perform for concrete and cement matrix and required attention to many test details. Amongst there is specimen alignment and post crack stability. The use of uniaxial tension test for characterizing the properties of RPC is much easier. Actually the purpose of characterizing tensile stress-strain behavior of HPFRCC is to obtain constitutive relations of material that can be used directly for the elements subjected to simple state of stress. For more complicated structural geometry or loading configuration it will be necessary to generalize the experimentally obtained uniaxial stress strain curve into multiaxial stress strain constitutive relation. The Strain measured can be interpreted as the smeared and averaged elongation over the gauge length when strain gauge is long enough compared with spacing between adjacent micro cracks. Specimen configuration and associated jigging facility some time may avoid auxiliary instrument for deformation measurement. Automatic data acquisition system in MTS senses displacement of actuator which can be considered directly as an extension of a specimen, if slippage is prevented. Evaluation of strength in axial tension requires complicated test setup, time consuming testing procedures and expensive experimentation.

Split tensile test seems to be the best option to get tensile strength indirectly for the cementitious composite; it is accepted since long as it is easy to cast the cylindrical specimen and simple to perform avoiding all complication of axial tension test. For ordinary concrete well known correlation exists between direct tensile strength and splitting tensile strength from which estimation of true tensile strength is possible and it is used in practice.However, to support these results a double punch tensile test can be used for indirect tensile strength of RPC (**k.T. chu,& X. X. wei 2007)**

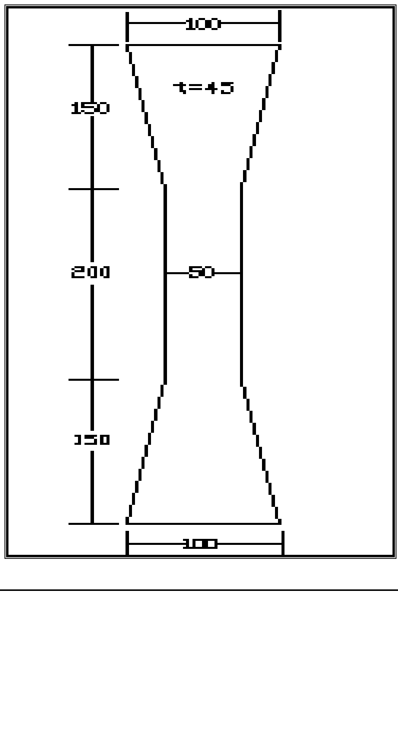

FIG. 1(MDB) SPECIMEN DIMENSIONS **FIG. 2 (MDB) TEST SETUP**

II. MODIFIED DOG BONE TEST FOR UNI- AXIAL TENSION

Dog bone specimen gives 3D effect of fibres orientation as its all dimensions are more than 3 times the fibre length. To improve the cracking pattern and to get reliable deformation mechanism, modified dog bone specimen is proposed with overall dimensions as shown in **Fig. 1** A specially designed fixture is fabricated to hold the specimen properly as shown is **Fig. 2.0** gauge length is kept as 168 mm in load displacement response, displacement is recorded with LVDT mounted on the specimen. All the specimens are tested under displacement control at a rate of 0.005 mm per second. Load and displacement at first crack and maximum stress are recorded to evaluate first crack strength and ultimate tensile strength. Three specimens are tested for each matrix after 28 days of normal water curing and average results of three specimens for each matrix are presented for discussion.

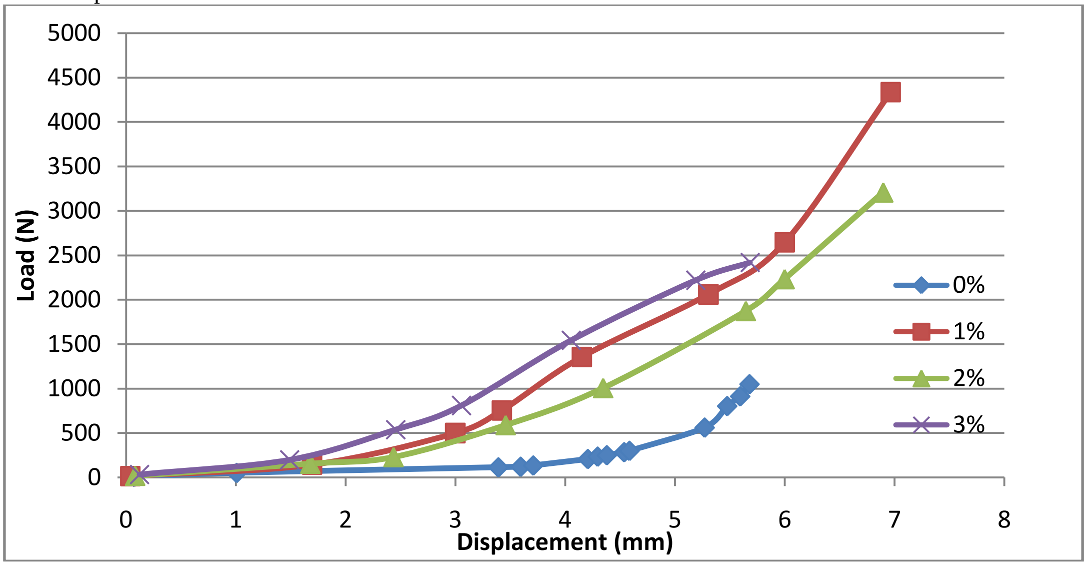

Fig.3.0 load-displacement relation for different % fibre content

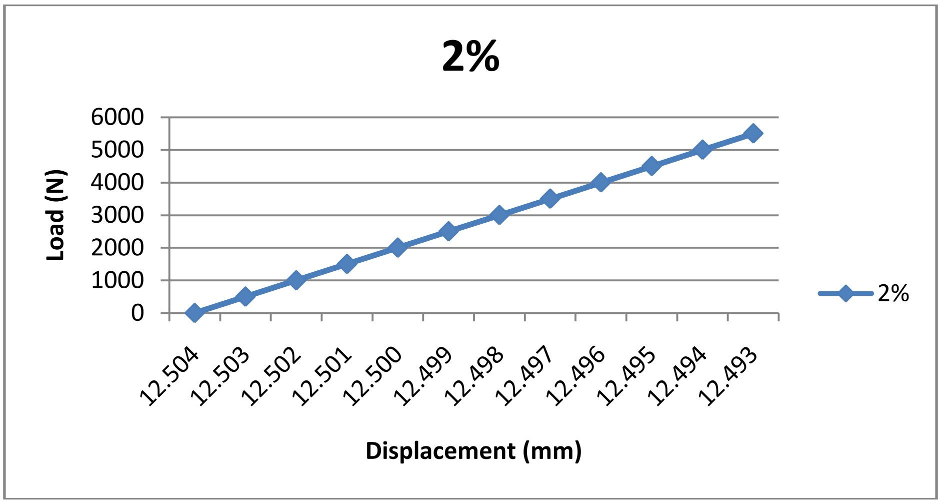

Fig.4.0 initial portion load-displacement relation of optimized RPC.

Yet, another test to find out the indirect tensile strength of concrete. In this test a concrete cylinder is placed vertically between the loading plates of the compression test machine and compressed by the steel punches located concentrically on top and bottom surfaces will cylinder. The loading arrangement and specimen are shown in **Fig.5.0.**

An ideal failure mechanism will consists of many simple tension cracks in a radial direction and two cone shaped rupture surfaces directly under the loads. Two cone shapes move towards each other as a rigid body and displace the surrounding material horizontally sideways. The formula for calculating the tensile strength has been calculated on the basis of limit analysis.

Double Punch Tensile Strength of RPC

The relation is proposed by **Chen and yuan (1980)**

$$fdp = \frac{0.75Pdp}{\pi(0.3DH - 0.25x^2)}$$

Where, Pdp = specimen failure load.

H = Height of specimen.
D = diameter of specimen.
X = diameter of steel punch.

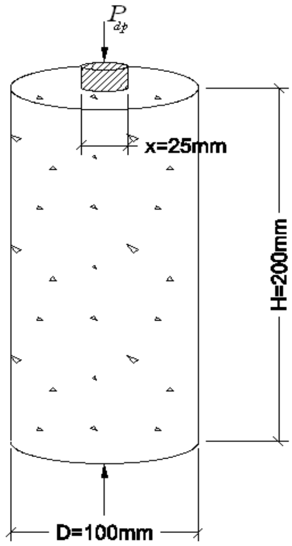

Fig 5.0: Double Punch Tensile Test Setup

Table 1.0 Results of Tensile Strength

Fiber %	Avg Double punch Tensile Strength (MPa)	Avg Split Tensile Strength (MPa)
0	5.107	5.150
1	7.163	8.035
2	8.035	10.016
3	7.367	9.167

FIG 6.0: DOUBLE PUNCH TENSILE TEST

III. RESULTS AND DISCUSSION

Ends of modified dog bone specimen are modified to reduce the stress concentration there is an enough space and it is easy to mount LVDT on this specimen to measure elongation over a gauge length for strain measurement. Wedge type geometry at the ends in the grip portion tends to slip a little bit when load is increased and load-displacement graph in which displacement of an actuator of MTS is considered as displacement of the specimen. This is not the real displacement of the specimen hence should not be referred for strain calculation. Therefore LVDT is mounted modified dog bone (MDB) specimens to measure deformation for strain calculation.

An experimental result shows that the tensile strength for RPC with inclusion of fibers increases considerably over its plain RPC. Tensile strength of 2% steel fiber greater than 0%, 1%, 3% fiber volume content. An experimental result obtained by split Tensile strength of cylinder is in concurrence with the double punch test. Cylinder splitting tensile strength is about 30 to 40 % higher than double punch tensile strength show in **Fig.7.0**.

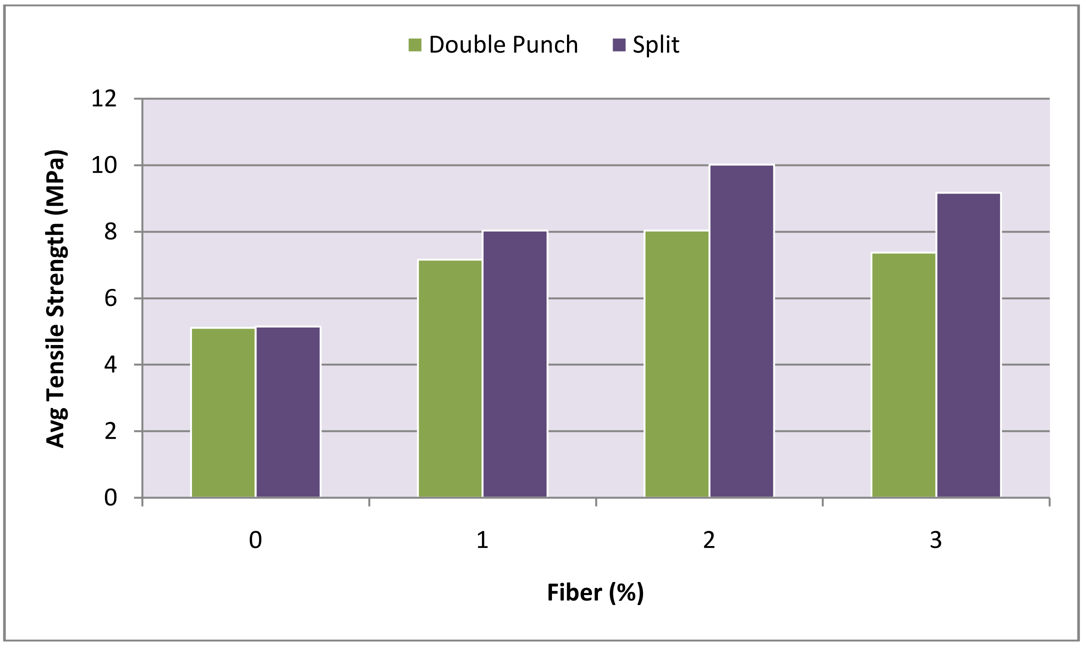

Fig.7.0: Av. Tensile Strength of Double Punch Test and Split Test

IV. CONCLUSIONS

1) Addition of Steel fibres increases Cylinder splitting tensile strength of RPC and optimum Results is obtained at steel fibre content of 0.2 parts by mass of cement.
2) Curing condition does not help in improving tensile strength it is also observed that more than one crack has developed so it does not fail in fracture mode, a ductile failure is taking place fibres get pulled out form matrix.
3) Specimen that has under gone heat treatment, the mean 28 days estimated cylinder splitting tensile strength of RPC was 11.0 MPa the range of calculated tensile strength was 9.52 to 12.9 MPa.
4) Tensile strength obtained by double punch tension test is approximately 30 to 40% lesser than the Cylinder splitting tensile strength.

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