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Elastic and Strength based Studies of Concrete in Filled Steel Tubular Section

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ABSTRACT: Reinforced cement concreteis one of the mostversatile and most used constructionmaterialanditsdiscoveryhasbeenaboontomankind.Itessentiallyconsistsofprovidingreinforcement in the form of twisted steel bars of varying diameter inthe concrete element toenhanceitstensile strength.Structural hollow sections made of steel make the most efficient compression members. Filling them with concrete gives further advantages, including higher load carrying capacity, reduced sectional dimensions resulting in slender members,etc.These hollow sections have an added advantage of not needing any formwork during the casting and installation. Inmodernconstruction,especiallyinthehousingsectoruseofprecastelementshasbecomeincreasingly popular. .In this project, we mainly aim in confining concrete into hollow steel tube,this confinement ofconcrete in the steel tubes also provides lateral stability to the elements which in turn increases the load carrying capacity, its flexuralstiffnessandrigidity.

KEYWORDS: Flexural stiffness, Anti rust, Anti-Corrosive, formwork, Hazardous, etc.

I. INTRODUCTION

GENERAL

Reinforced cement concrete is one of the most versatile and most used construction material and its discovery has been a boon to mankind. It essentially consists of providing reinforcements in the form of steel TMT or HYSD bars of varying diameter ranging from 8mm to 32mm in the concrete element to enhance its tensile strength, The steel reinforcement is provided as we know that concrete is very poor in resisting tensile stresses.

CONCRETE

Concrete essentially consists of four main components. namely Ordinary Portland Cement (OPC), fine aggregate (IS 4.75mm to 600 microns), coarse aggregates (IS 12.5mm to 4.75 mm), potable water and admixtures (mineral and chemical).Self-compacting concrete, (herein after refers as SCC), a new composite material, which can flow under its own weight over a long distance without segregation and to achieve consolidation without the use of vibrators, seems to be one of the solutions to solve all those constructions related problems. The use of SCC has potentially reduced the required labors by more than 50%.

The advantages of SCC

Improved ability of concrete to flow into intricate spaces and between congested reinforcement.

1. Improved form surface finish and reduced need to repair defects such as bug holes and honeycombing.
2. Reduced construction costs due to reduced labor costs and reduced equipment purchase and maintenance costs.

The disadvantages of SCC:

1. Increased material costs, especially for admixtures and cementitious materials.
2. Increased formwork costs due to possibly higher formwork pressures.
3. Increased technical expertise required to develop and control mixture.

Steel

Structural hollow sections made of steel make the most efficient compression members, filling them with concrete may give further advantages, which may include higher capacity, reduced section diameter etc.These sections have the added advantage as there is no need of any formwork during the casting as well as there is no requirement of fabrication of the reinforcements which in turn reduce the labor work as well as cost.One more advantage of such sections is that concrete is not exposed to the environment but the drawback here is the exposure of steel to the environment which can be tackled by coating the steel member with suitable coatings.In modern construction, especially in the housing sector use of precast elements has become increasingly popular, these elements can be used as precast members in case of damage to the structure, repair maintenance works etc. In this project, we mainly aim in confining concrete into hollow steel tubes thereby eliminating the conventional reinforcement. this confinement of concrete in the steel tubes also provides lateral stability to the elements.

Need For This Study

This study and experimentation on Concrete in-filled tubular sections is mainly due to the following reasons.

1. There is no formwork required during its casting
2. There is no need of fabrication of reinforcements
3. Concrete that is cast is not exposed to the environment
4. Concrete being susceptible to fire hazards is protected here, though the steel is exposed, it offers better resistance when compared to concrete
5. This project has many applications in precast works, repair and maintenance works, rehabilitation and retrofitting applications etc.

Objective of The Study

1. Steel members have the advantages of high tensile strength and ductility, while concrete members have the advantages of high compressive strength and stiffness.
2. Composite members combine steel and concrete, resulting in a member that has the beneficial qualities of both materials.
3. Here the strength and elastic properties of such beams will be studied. The behaviour of concrete in-filled tubular sections under shear, flexure as well as compression will the studied.
4. The theoretical analysis of such beams will be carried out by the finite element analysis method.

Scope of the Work

1. The scope ~~is limited to~~ the materials used for the experiments, which are:
2. Hollow rectangular steel section of 1 gauge measure only.
3. One grade of SCC concrete of M20
4. Testing is restricted to only flexure and compression.
1. Comparison between the experimental results and the analytical re~~sults.~~

Preparation of Steel specimens – Hollow

Stainless steel rectangular hollow tubes having the following characteristics is used for the all the experiments:

Grade of steel: 202
Tensile strength: 515Mpa
Elastic modulus: 207GPa
Poisson's ratio: 0.27

The specimen was 6.5m factory made. This was later cut into four specimens of 1.2m length for flexure tests and 0.2m for compression tests.

Compression specimens

1. Two hollow specimens were prepared for compression test.
2. The gross length of the specimens was 0.2m and the gauge length was fixed to 0.1m to accommodate the dial gauge Indents were made into the specimens to enable for the fixing of the De-mech gauge (Demountable Mechanical gauge). This gauge is used for getting the deflection of the specimen under loading.

Flexure specimens

1. Two hollow specimens were prepared for flexural testing.
2. The gross length of the specimens was 1.2m and had an effective length of 0.9m.
3. A thin metal strip was attached at the mid span to facilitate for fixing of the dial gauge required to record deflections during the load application.

Concrete Mix Design

SCC Mix design adopted is based on Volume Fraction method. Notations used:

V - Volume of concrete
w.k.t.:
V = Vp + Vag and
Vp = Vc + Vfly + Vw taking
Water = 190 l/cu.m,
Cement content = 250 kg/cu.mand Vp = 0.37

0.37 = Vc +Vfly + Vw
0.
37 =

Vp - Volume of paste (cement + fly ash + water)
Vag - volume of aggregates(fine + coarse)

+ Vfly + 0.190

Vfly = 0.4 - - 0.90
Vfly = 0.10
Weight = 0.2 * 2.1 * 1000 = 211 kg/cu.m
Vag = 1.00 - 0.37 = 0.63

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Taking the fine aggregate to coarse aggregate ratio as 55:45 Vfa = 0.55 * .63 * 2.68 * 1000 = 928.62 kg/cu.m
Vca = 0.45 * 0.63 * 2.68 * 1000 = 760.0 kg/cu.m

Dosage of Super plasticizers = 0.9% by weight of Cement.

The mix proportion works out to:
Ordinary Portland Cement - 250 kg/m3
Fly Ash - 211 kg/m3
Water - 190 lt/m3
Fine aggregate - 928 kg/m3
Coarse aggregate - 760 kg/m3

Mix Proportion ratio works out to be = 1: 0.84: 3.7: 3.0 (Cement: Fly ash: Fine aggregate: Coarse aggregate)

Average slump flow obtained from the above mix = 615mm which is found to be satisfactory.

Compression specimens
Two hollow specimens were prepared for compression test.
The gross length of the specimens was 0.2m and the gauge length was fixed to 0.1m to accommodate the dial gauge
Indents were made into the specimens to enable for the fixing of the De-mech gauge (Demountable Mechanical gauge). This gauge is used for getting the deflection of the specimen under loading.
These specimens were levelled and filled with SCC concrete mixed as per the above design and were left to cure for 28 days.
The ends of the tubes were sealed using polyurethane membrane and cello tape thereby ensuring that there is no evaporation of water.

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Tests on Self-Compacting Concrete
Introduction
Many different tests methods have been in attempt to characterize the properties of SCC so far, no single method or combination of methods has achieved universal approval and most of them have their adherents. Similarly, no single methods have been found which characterizes all the relevant workability aspects so each mix design should be tested by more than one test method for different workability parameters. Typical acceptance criteria for SCC with a maximum aggregate size up to 20mm are shown in Table.2.1

TABLE 2.1: List of Test Methods for Workability Properties of SCC.

SL.NO	METHOD	PROPERTY
1	SLUMP FLOW BY ABRAMS CONE	FILLING ABILITY
2	T50 cm SLUMP FLOW	FILLING ABILITY
3	J-RING	PASSING ABILITY
4	V-FUNNEL	FILLING ABILITY
5	V-FUNNEL AT 5 MINUTES	SEGGREGATION RESISTANCE

6	L-BOX	PASSING ABILITY
7	U-BOX	PASSING ABILITY
8	FILL-BOX	PASSING ABILITY
9	GTM SCREEN STABILITY TEST	SEGGREGATION RESISTANCE
10	ORIMET TEST	FILLING ABILITY

TABLE 2.2: Acceptance Criteria for SCC

SL. NO	METHOD	UNIT	MINIMUM VALUE	MAXIMUM VALUE
1	Slump Flow by Abrams Cone	mm	650	800
2	T50 cm Slump Flow	Sec	2	5
3	J-RING	mm	0	10
4	V-FUNNEL	Sec	6	12
5	V-FUNNEL AT 5 MINUTES	Sec	0	+3
6	L-BOX	h2/h1	0.8	1.0
7	FILL-BOX	%	90	100

Slump Flow Test and T50cm Test:

The slump flow is used to assess the horizontal free flow of SCC in the absence of obstructions. It was first developed in Japan for use in assessment of underwater concrete. The test method is based on the test method for determining the slump. The diameter of the concrete circle is a measure for the filling ability of the concrete.

Assessment of Test:

This is a simple, rapid test procedure, though two people are needed if the T50 time is to be measured. It can be used on site, though the size of the base plate is somewhat unwieldy and leveled ground is essential. It is the most used test and gives a good assessment of filling ability. It gives no indication of the ability of the concrete to pass between reinforcement without blocking but may give some indication of resistance to segregation. It can be argued that the completely free flow, unrestrained by any boundaries, is not representative of what happens in practice in concrete construction, but the test can profitably be used to assess the consistency of supply of ready-mix concrete to a site from load to load.

Equipment:

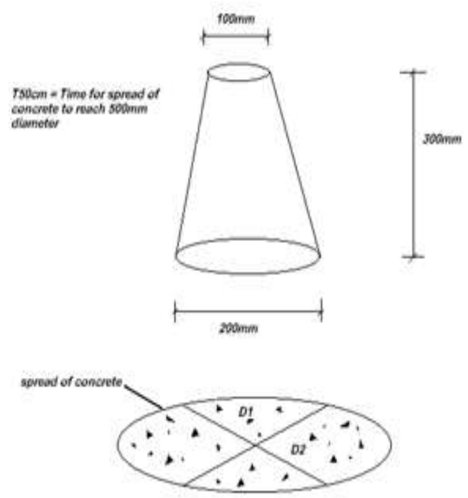

Fig. 2: Slump Flow and T50cm Test

Mould in the shape of a truncated cone with an internal dimensions 200mm diameter at the base, 100mm diameter at the top and a height 300mm, confirming to EN 12350-2.

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Base plate of a stiff non-absorbing material, at least 700mm square, marked with a circle marking the central location for the slump cone.
Trowel.
Scoop.
Ruler.
Stopwatch (optional)

Procedure:
About 6 liters of concrete is needed to perform the test, sampled normally.
Moisten the base plate and inside the slump cone.
Place base plate on a level stable ground and the slump cone centrally on the base plate and hold down firmly.
Fill the cone using the scoop. Do not tamp, simply strike off the concrete level with the top of the cone with the trowel.
Remove any surplus concrete from around the base of the cone.
Raise the cone vertically and allow the concrete to flow out freely.
Simultaneously, start the stopwatch and record the time taken for the concrete to reach the 500mm-spread circle (this is the T50 time).
Measure the final diameter of the concrete in two perpendicular directions.
Calculate the average of the two measured diameters (this is the slump flow in mm).
Note any border of mortar or cement paste without coarse aggregate at the edge of the pool of concrete.

Interpretation of Results:

The higher the slump flow (SF) value, the greater is its ability to fill formwork under its own weight. A value of at least 650mm is required for SCC. There is no generally accepted advice as to whatever the reasonable tolerances about a specified value are, though 50mm, as with the related flow table test, might be appropriate.

The T50 time is secondary indication of flow. A lower time indicates greater flowability. The BriteEuRam research suggested that a time of 3 to 7 seconds is acceptable for civil engineering applications, and 2 to 5 seconds for housing applications. In case of severe segregation most coarse aggregate will remain in the center of pool of concrete and mortar and cement paste at the concrete periphery. In case of minor segregation, a border of mortar without coarse aggregate can occur at the edge of the pool of the concrete.

II. FUNNEL TEST AND V-FUNNEL TEST AT 5 MINUTES

The test was developed in Japan and used by Ozawa Et Al (5). The equipment consists of a V-shaped funnel, shown in figure. An alternative type of V-funnel, the O funnel, with a circular section is also used in Japan.

The described V-funnel test is used to determine the filling ability (flowability) of the concrete with a maximum aggregate size of 20mm. The funnel is filled with about 12 liters of concrete and the time taken for it to flow through the apparatus measured.

After this the funnel can be refilled with concrete and left for 5 minutes to settle. If the concrete shows segregation, then the flow time will increase significantly.

Assessment of the Test:

Though the test is designed to measure flow ability, the result is affected by concrete properties other than flow. The inverted cone shape will cause any liability of the concrete to block to be reflected in the result –if, for example there is too much aggregate. High flow time can also be associated with low deformability due to a high paste viscosity, and with high inter-particle friction. While the apparatus is simple, the effect of the angle of the funnel and the wall effect on the flow of concrete are not clear.

Equipment:
V-Funnel.
Bucket (12 litres).
Scoop.
Stopwatch.

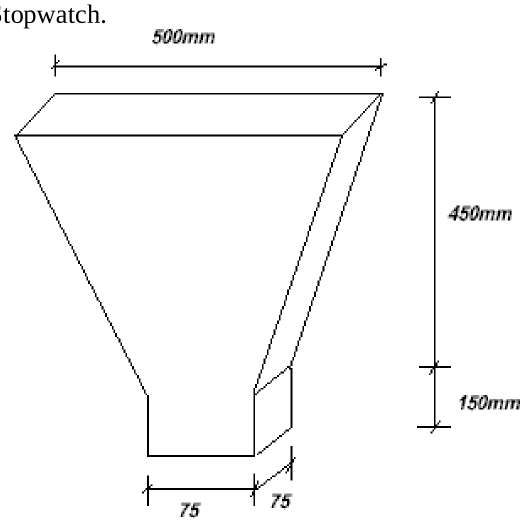

Fig.3. V-Funnel Test Apparatus

Procedure:
About 12 litres of concrete is needed for perform the test, sampled normally.
Set the V-Funnel firm on the ground.
Moisten the inside surfaces of the funnel.
Keep the trap door open to allow any surplus water to drain.

Close the trap door and place a bucket underneath.
Fill the apparatus completely without compacting or tamping, simply strike off the concrete level with the top with the trowel.
Open within 10 seconds after filling the trap door and allow the concrete to flow out under gravity.
Start the stopwatch when the trap door is opened and record the time for the discharge to complete (the flow time). This is taken to be when light is seen from the above through the funnel
The whole test must be performed within 5 minutes.

III. CONCLUSION:-

It is found out that both hollow as well as in-filled specimens have their own merits as well as demerits.
It can however be noted In-Filled specimens displayed higher load carrying capacity when compared to hollow specimens.
In-Filled specimens failed by cracking off the tensile face when subjected to flexure testing, when compared to hollow specimens which failed due to local buckling at the points of loading as evident from the photographs taken during the testing process.

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