Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 48 (1985)

Artikel: Behaviour of concrete in-filled tubular columns

Autor: Srinivasan, C.N.

DOI: https://doi.org/10.5169/seals-37474

Nutzungsbedingungen

Die ETH-Bibliothek ist die Anbieterin der digitalisierten Zeitschriften auf E-Periodica. Sie besitzt keine Urheberrechte an den Zeitschriften und ist nicht verantwortlich für deren Inhalte. Die Rechte liegen in der Regel bei den Herausgebern beziehungsweise den externen Rechteinhabern. Das Veröffentlichen von Bildern in Print- und Online-Publikationen sowie auf Social Media-Kanälen oder Webseiten ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. Mehr erfahren

Conditions d'utilisation

L'ETH Library est le fournisseur des revues numérisées. Elle ne détient aucun droit d'auteur sur les revues et n'est pas responsable de leur contenu. En règle générale, les droits sont détenus par les éditeurs ou les détenteurs de droits externes. La reproduction d'images dans des publications imprimées ou en ligne ainsi que sur des canaux de médias sociaux ou des sites web n'est autorisée qu'avec l'accord préalable des détenteurs des droits. En savoir plus

Terms of use

The ETH Library is the provider of the digitised journals. It does not own any copyrights to the journals and is not responsible for their content. The rights usually lie with the publishers or the external rights holders. Publishing images in print and online publications, as well as on social media channels or websites, is only permitted with the prior consent of the rights holders. Find out more

Download PDF: 28.11.2025

ETH-Bibliothek Zürich, E-Periodica, https://www.e-periodica.ch



Behaviour of Concrete In-Filled Tubular Columns

Comportement des colonnes mixtes formées de tubes remplis de béton

Verhalten von betongefüllten Stahlhohlprofilstützen

C.N. SRINIVASAN
Partner
M/s C.R. Narayana Rao
Madras, India



Completed his Under-Graduate Degree in Indian Institute of Technology, Kharagpur. Got his Post-Graduate Degree and Training in United States. He is involved in Design of Structures, both Concrete and Steel for Industrial Buildings and High rise buildings.

SUMMARY

Concrete in-filled tubular columns represent a class of structure where the best properties of steel and concrete are used to their maximum advantage. Aspects governing strength and behaviour over the entire range of loading have been studied and capacity interaction diagrams proposed based on the stress strain relationship for the constituent material properties.

RÉSUMÉ

Les colonnes mixtes formées de tubes remplis de béton représentent le type d'élément structurel utilisant au mieux les caractéristiques de l'acier et du béton. Les phénomènes gouvernant leur comportement et leur résistance face aux différentes sollicitations possibles sont étudiés et des diagrammes d'interactions basés sur les relations contrainte-dilatation des matériaux constitutifs sont donnés.

ZUSAMMENFASSUNG

Betongefüllte Stahlhohlprofilstützen stellen ein Bauelement dar, bei dem die besten Eigenschaften von Stahl und Beton am vorteilhaftesten kombiniert werden. Aspekte, welche die Festigkeit und das Verhalten über den ganzen Belastungsbereich beeinflussen, wurden studiert, und ein Tragfähigkeitsinteraktionsdiagramm wird aufgrund des Spannung-Dehnungs-Verhältnisses der beteiligten Materialien vorgeschlagen.



Generate in-filled tubular columns represent a class of structure where the best properties of steel and concrete are used to their maximum advantage. The following aspects governing the strength and behaviour have been studied. (1)

- 1. Confining action in circular and square CITC.
- 2. Triaxial effects on the core and biaxial effects on the shell.
- 3. Presence of lateral strain compatibility and complete interaction of core and the shell, over entire range of loading.
- 4. Effect of method of loading and a study of connections.
- 5. Factors governing the service and the ultimate load behaviour.

The test programme included -

In the first phase, 150 mm dia circular and square tubes of 300 mm to 1200 mm lengths were tested to develop a stress strain relationship for core and shell and to study items 1 to 3 above. 6 Nos. circular short specimens of CITC have been tested to verify the validity of the proposed lead-strain relationship.

In the second phase, CITC, of lengths 1200 mm, 1840 mm and 2500 mm have been tested for both axial and eccentric leaded conditions and to study the connection details and transfer of load from horizontal (beams and slabs) to vertical member (CITC).

A total of 12 specimens were tested for axially loaded condition, out of which 8 were for the study of connections. 13 specimens were tested for eccentrically loaded condition. In addition, 8 specimens were tested to study the presence of bond at the concrete steel interface. 6 specimens were tested to study the effect of k, the lateral load enhancement factor with slenderness ratio.

Table I and II summarises the results of eccentrically and axially loaded sections. Fig. 1 shows a specimen under test.

Stress strain relationship of the constituent materials of the CITC was studied to prepare an equivalent stress strain relationship for the late-rally confined core of concrete and biaxially stressed steel shell (overcoming the difficulty of defining the areas of cross section and ratios of module of the constituent materials) that would be applicable for the entire range of loading, taking into account progressively increasing degree of confinement applied continuously over the length of the specimen.

The following additional factors affecting stress strain relationship have been studied.

- 1. Effect of lateral load enhancement factor with reference to slenderness.
- 2. Effect of variation of Poisson's ratio of concrete with stress level and its effect on bond between core and shell.
- 3. Percentage load carried by shell and core over the entire range of loading, which reverses from service load to ultimate load requiring different load factors are to be applied to service load and ultimate load stages. (Fig. 2)

As opposed to reinforced concrete columns and concrete encased steel columns, in the CITC, lateral strain compatibility and composite action is absent upto a load level, $\frac{P}{P_{v}}$ = 0.50. Consequently, the core of CITC is laterally



confined at advanced stages of loading only and at the earlier stages of loading it is under a uniaxial stage of stress. Thus for a realistic representation of actual behaviour under progressively increasing loads, different stress-strain relationship are to be employed to represent service stage and ultimate stage behaviour. Based on all the foregoing, a stress strain relationship is proposed. (1) (2)

Based on the study of connections (beam to column and flat slab to column) on the strength and behaviour, it is concluded that methods of transferring load from horizontal members (beam or slabs) to vertical members (CITC) affect the strength and behaviour of CITC as also the load-strain behaviour of constituent material. Flat slab to column type of connection, particularly when the connection is such, where the shell and core are loaded together or where the core alone is loaded (Fig. 3) is an effective connection detail, where the enhanced strength of the concrete core, is best exploited. Beam to column type of connection where shell alone is loaded first, does not lend itself for a proper exploitation of CITC. In fact this type of connection is unsafe and not reliable.

Capacity interaction formulae for square and circular CITC, for service and ultimate load stages, based on the true stress strain curves for CITC, and taking into account percentage of load shared by the core and the shell of different stages of loading, have been developed. A typical interaction diagram for circular and square CITC is shown in Fig. 4 and 5. Effect of wall thickness, diameter and strength of concrete mix have also been studied in this investigation.

On the study of the square and circular CITC, the strength and behaviour of square and circular CITC are governed by different parameters. The confinement effect of a circular shell is far higher than the square one, all the more so, if beam to column type of bracketted connections are employed, i.e., when the connection transfers the force to the shell of the column. CITC shows large enhancement of load carrying capacity and can sustain large strains and deformations. This reserve of strength and deformation makes CITC, as ideal structural element in certain special conditions, as in a seismic design. This study has indicated that for effective exploitation of CITC, high strength tubes are to be employed. In the ranges tested, i.e., relatively short specimen of $\frac{1}{d}$ <12 and small eccentricity $\frac{c}{d}$ <0.2, the failure load is even more than one and a half times the failure load calculated employing uniaxial stress strain relationship for steel and concrete.

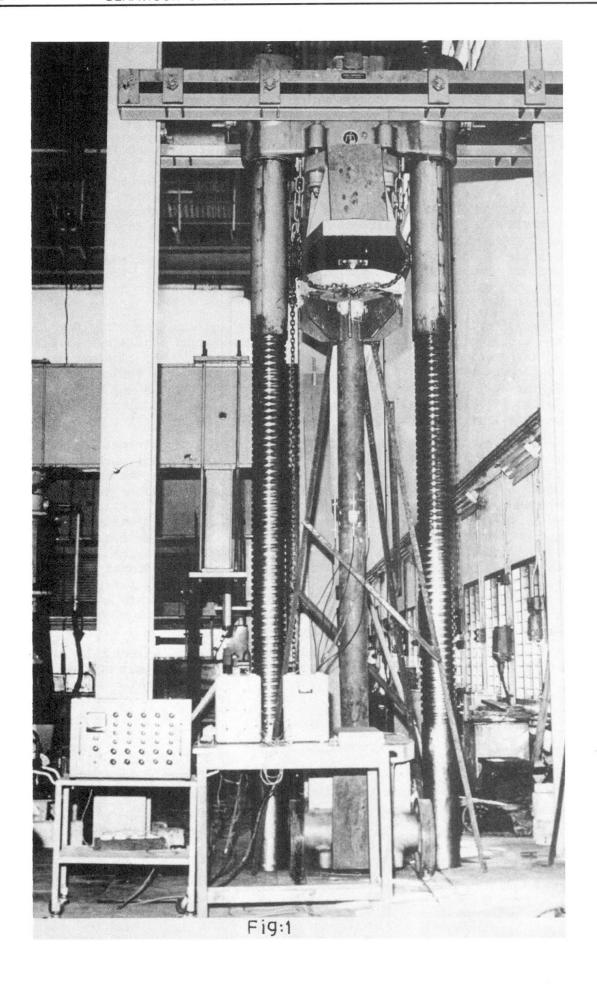
A design method to take into account the enhanced strength is proposed in this study. A design method has also been developed as a part of this study.

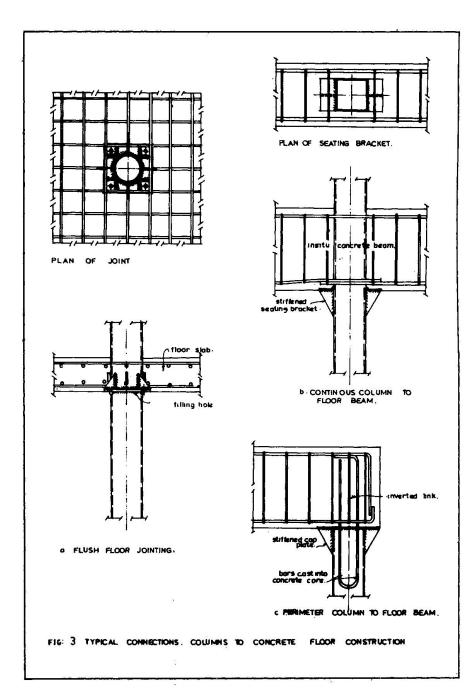
REFERENCES

- 1. SRINIVASAN C.N. Behaviour of Concrete In-filled Tubular Columns.

 Thesis submitted for the award of Doctor of Philosophy Indian Institute of Technology, Madras 1981.
- 2. SEN H.K. Triaxial effects in concrete filled Tubular Steel Columns. Thesis submitted to University of London 1969.







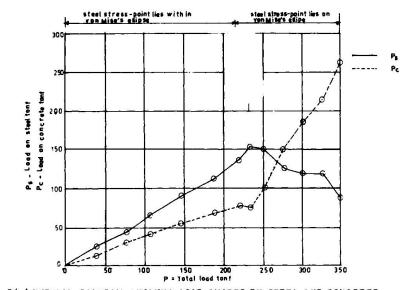
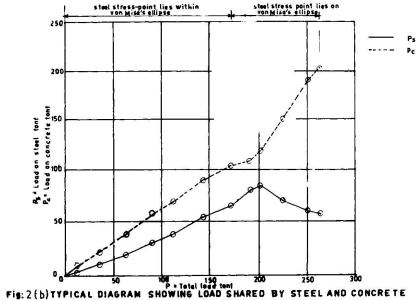
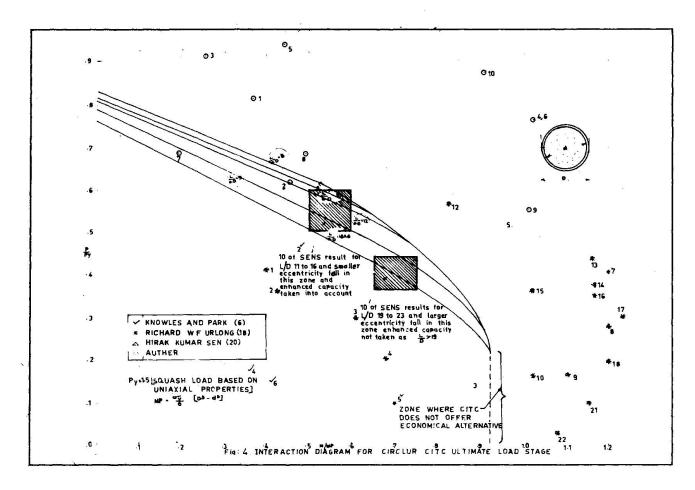


Fig: 2(q) TYPICAL DIAGRAM SHOWING LOAD SHARED BY STEEL AND CONCRETE OVER ENTIRE RANGE OF LOADING (BASED ON SEN. 22)



OVER ENTIRE RANGE OF LOADING (BASED ON SEN. 22)





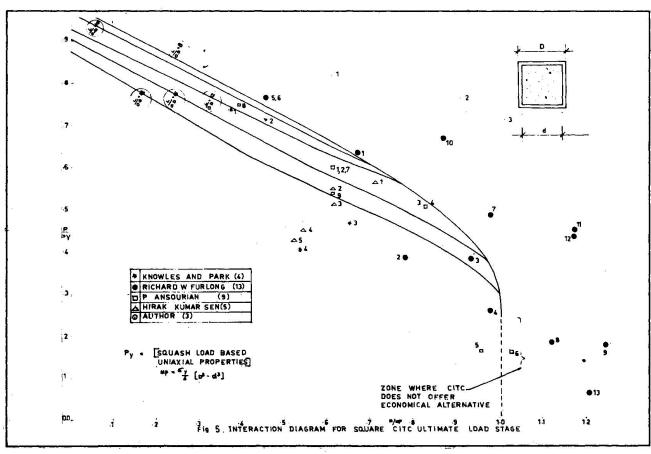




TABLE I

TEST RESULTS OF AXIALLY LOADED SPECIMEN TO STUDY THE INFLUENCE OF METHOD OF LOADING.

DESCRIPTION: 15 cm, nominal dia. or 15 cm. square x 6 mm wall thickness x 122 cm long tube infilled concrete corresponding to a 15 cm cylinder strength of 300 kg/cm²

Brief Description of Loading.	Failure load (Tonne)	Observations at Failure.
Infilled circular tube core only loaded.	1:85	Formation of Luder Lines and spalling of mill scales and kind at mid-height.
Infilled circular tubes both shell and core loaded.	200	Luder lines with spalling of mill scales and kink at mid- height.
Infilled circular tube, bracketed arrangement beam to column type connection—shell loaded.	110	Bulges at top and local buckling.
Hollow circular tube.	90	Bulges at top and local buckling.
Infilled circular tube, shell only loaded.	85	Bulges at top and local buckling.
Infilled eircular tube flat slab to column connection core and shell loaded.	205	Formation of Luder lines, beading with kink at mid-height.
Square tubes - core only loaded.	200	Cracks formation at the welds
Square tubes - both core and shell loaded.	240	Cracks at the welds.
Infilled square tube-bracketed arrangement, *Beam to Column* type connection - shell loaded.	120	Bulges at top and local buckling.
Hollow square tube.	7 5	Bulges at top and local buckling.
Infilled square tube, shell only loaded.	88	Bulges at top and local buckling.
Infilled square tube - flat slab to column type connection - core and shell loaded.	250	Formation of Luder lines and bending with kink at mid-height.

TABLE II TEST RESULTS OF ECCENTRICALLY LOADED CIRCULAR AND SQUARE CITC.

DESCRIPTION:

(1)			dia.	X	6	mm	wall	thickness
	Ciron	TOTAL CAME						

Circular CITC. 122 cm. long. (2) Do Do 184 cm. long. (3) Do Do 250 cm. long. (4) 15 cm. x 15 cm. x 6 mm square CITC. 122 cm. long.

Concrete mix of the infill corresponds to 15 cm. cylinder strength of 200 kg/cm.²

S.No. Brief Description.	Length in cm.		load in	_				
1. Circular CITC Core only loaded.	184	1.0	118.0	Core only loaded with loading head-bearing				
Do	184	1.6	98.0	through 5 cm. thick close fitting loading				
Do	122	0.6	133.0					
 Circular CITC Core and shell loaded. 	122	1.0	140.0	Concrete face fini- shed smooth.				
Do	122	3.0	120.0					
Do	250	0.6	100.0					
 Gircular CITC beam to co- lumn type bracketed con- nection shell only loaded. 	122	1.5	100,0	Shell only leaded through stiffened bracket.				
Do	250	4.0	80.0					
4. Circular CITC- Flat slab to column type connection Core and shell loaded together.	122	2.0	127.0					
5. Square CITC- Core and shell loaded.	122	2.5	112.0	Concrete face fini- shed smooth.				
6. Square CITC beam to column type bracketed connection shell only loaded.	122	4.0	105.0					
Do	122	5.0	95.0					
Enhanced Failure load of Circular CITC								
(under axial load).			145.35	tonnes.				
Failure load of Square CITC (under axial load).			134.00	•				
Moment capacity of circular	CITC.		306.78	w cm.				
Moment capacity of square CI	TC.		459.00	₩ Cm _e				