Push Out Test for Concrete Filled Steel Tubular Using Different Strengths of Ultra High Perfomance Concrete

Name : Muhammad Zulfaqar Bin Abdul Razak

ID No. : 17010089

Supervisor : Dr. Ehsan Nikbakht Jarghouyeh

Int. Examnier : Prof. Nasir Shafiq

Ext. Examiner : Ir. Khairul Anwar Masu'd

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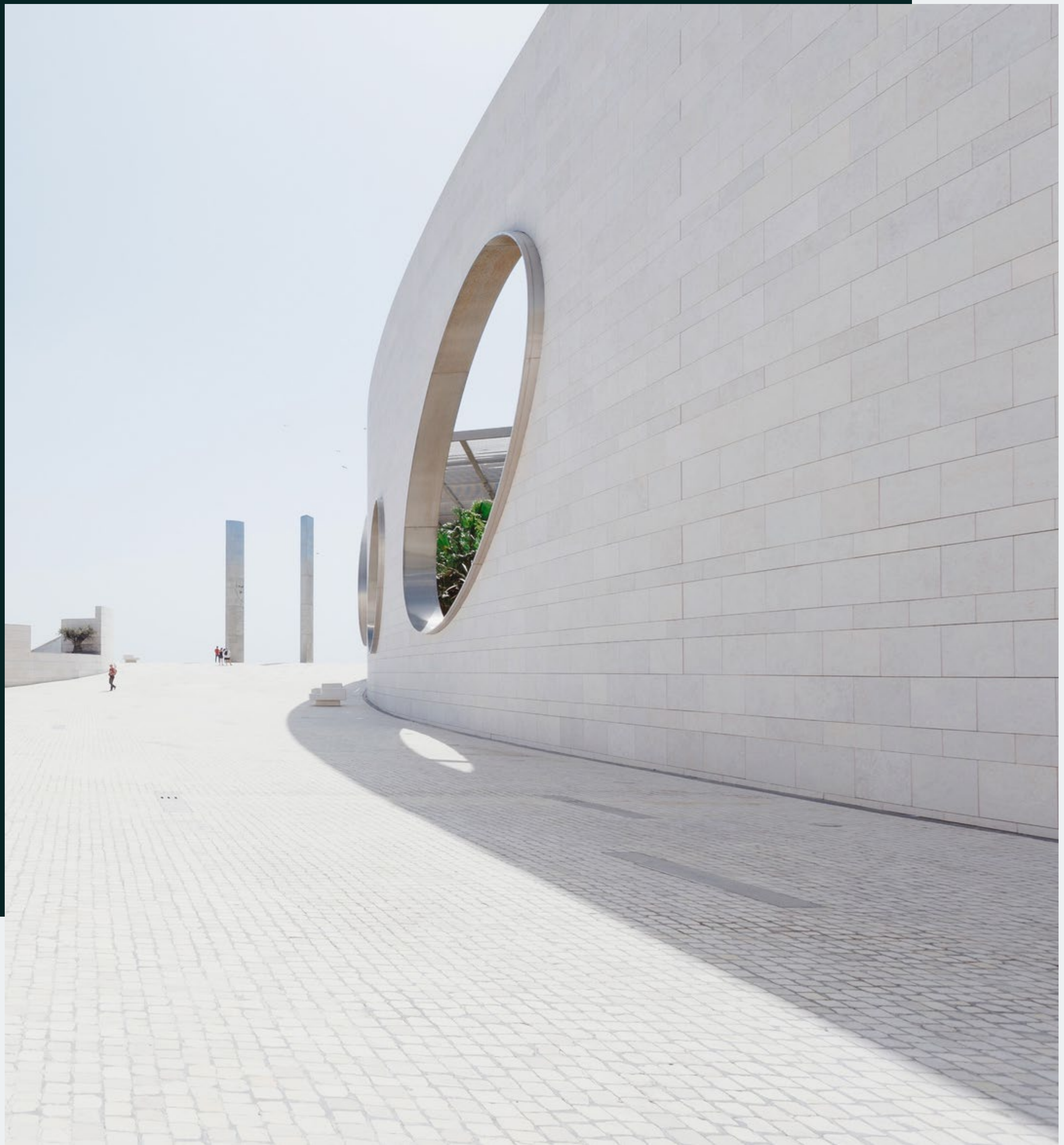
Introduction



Concrete Filled Steel Tubular

A hollow steel tubular filled with concrete or reinforced concrete.
High strength, stiffness and ductility
High rise buildings, bridges piers

Composite Action

Transfer of stress between the concrete and steel.
Bonding strength between the steel and concrete.
Cross section, dimension, age, type, roughness, strength

Problem Statement

There is a lack of consensus regarding the effect of high compressive strength on bond strength between the steel and concrete in CFST where some stated a similar trend with normal concrete and some the opposite

(Xiushu et al., 2015, Xu et al., 2009, Morishita et al., 1979)

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Objective and Scope of Study

Objective

To examine the interaction between the compressive strength of concrete core and bonding strength of steel and concrete in CFST

Scope of Study

Concrete Filled Steel Tubular

- Casting CFST samples
- Push Out Test
- Analysis

Ultra High Perfomance Concrete

- Design Mix
- Compressive Strength of 120Mpa
- Trial Mixes

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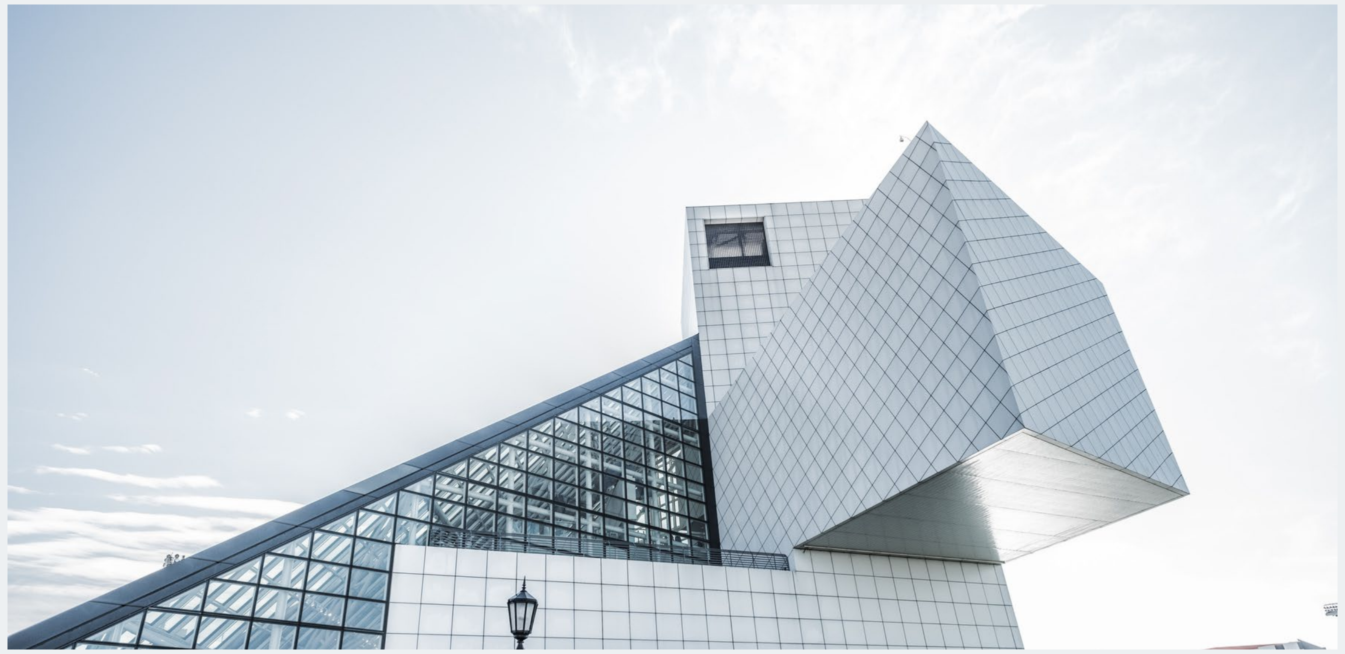
Literature Review



CFST Mechanical Properties

- Adequate confinement delays the local buckling.

"Manikandan and Umarani, 2021"

- Load bearing capacity improves with grade of concrete

"Tao, Uy, and et al., 2011"

Composite Action

- Mechanical properties can be improved due to composite action between steel and concrete.

"Han et al., 2014"

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Literature Review

Mechanism of Bonding Strength

Arise from the combination of mechanisms, Chemical Adhesion, Microlocking, Macrolocking

Macrolocking - due to manufacturing tolerances associated with internal dimensions.

Microlocking - caused by surface roughness in microscopic scale.

Chemical adhesion - insignificant and influenced by various factors such as w/c ratio.

(Tao et al. 2011, Virdi and Dowling 1975, Chen et al. 2009)

Macrolocking was the main mechanism in CFST columns contributing to the bond strength followed by friction, and the influence of chemical adhesion was very limited.

(Zhong et al., 2016)

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Methodology

Compression Test

01 UHPC Material Preparation
GGBS, Silica, Ground Quartz, Steel fiber, water reducer

02 Trial Mix
3 samples per mix with 3, 7, 28 days of curing

03 Compression Test
The compressive strength which is needed to be more than 120Mpa

Push Out Test

04 Steel Tubular Preparation
Prepare the steel hollow required

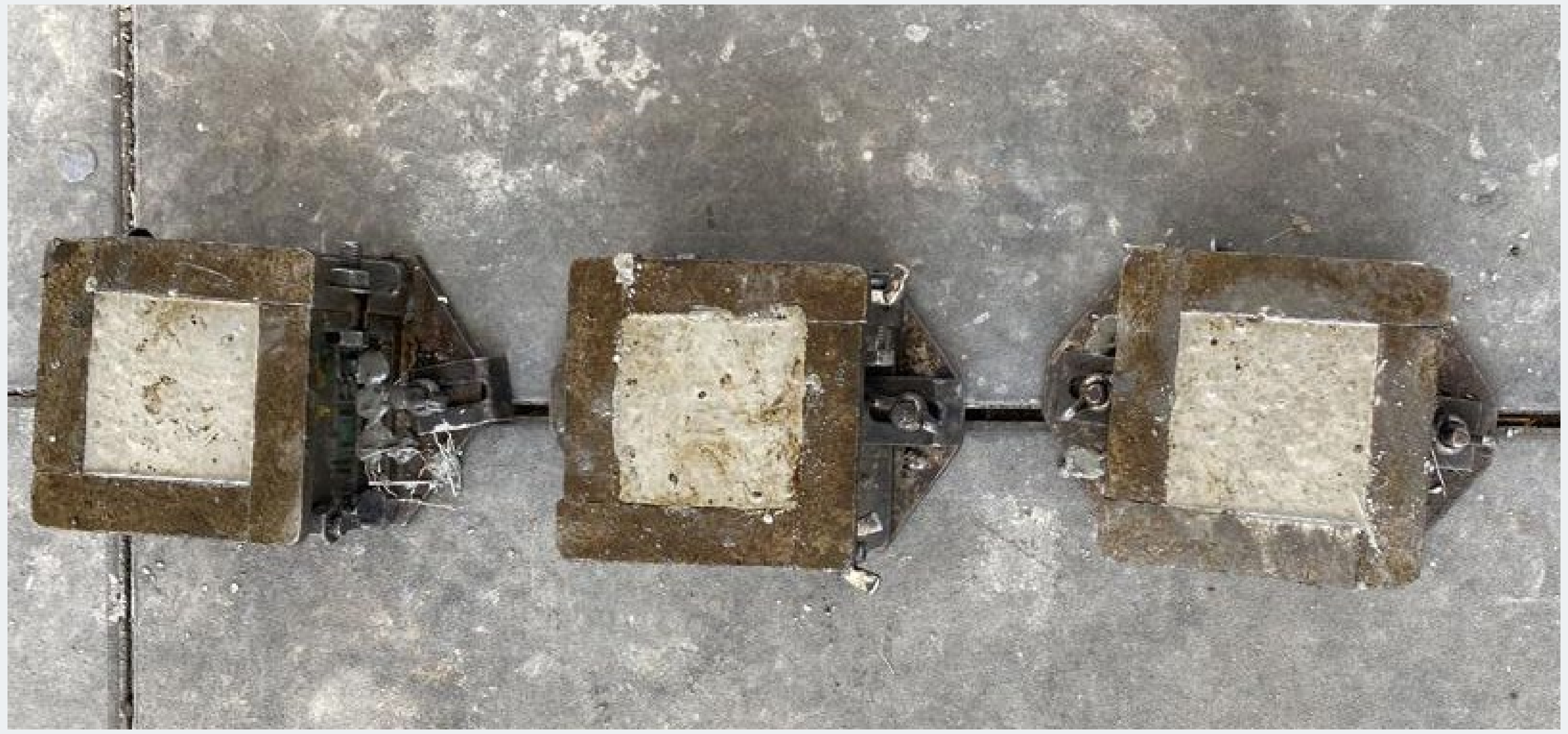
05 Casting CFST Sample
Casting UHPC inside the steel hollow

06 Push Out Test
Applied load to the concrete core of CFST

Materials Preparation

Material Preparation

To utilize UHPC, the subsequent mix needs to achieve 120Mpa of Strength.
UHPC do not require aggregates, instead needs GGBS, silica, quartz, fly ash, water reducer



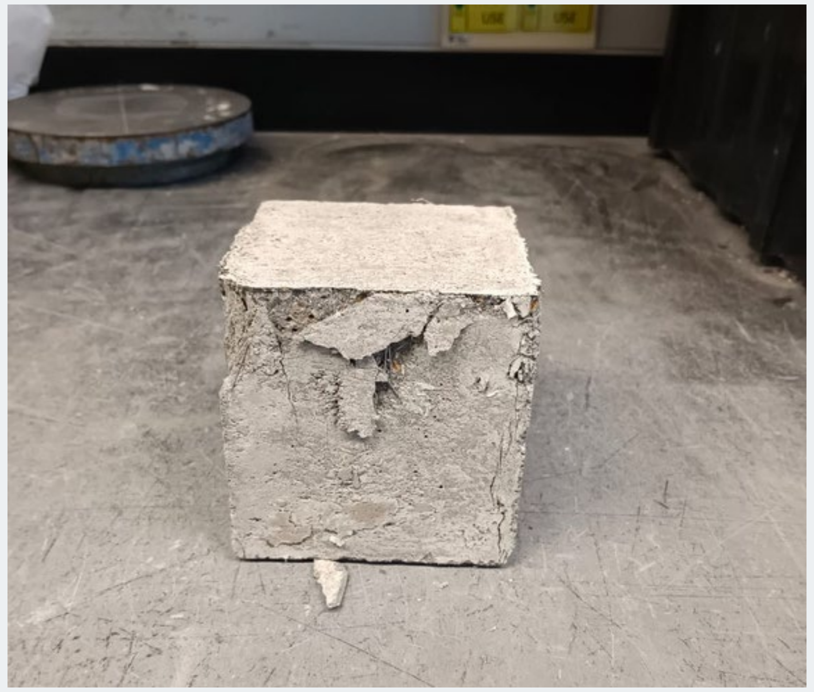
Trial Mix

Upon design mix, need to test the authentic of the design mix, hence trial mix.
A 100mmx100mmx100mm was used with 2 types of curing, heat and water.

UHPC Design Mix

Materials (kg/m^3)	BSI	Cemtec	Dura	BSI (2nd Trial)	Dura (2nd trial)	Ductal	Private Source	Private Source
Portland Cement	1114	1050	911	1114	911	712	1822	785
Fine Sand	1072	514	911	1072	911	1020	1822	1012.7
Silica Fume	169	268	225	169	225	231	450	251.2
Ground Quartz	-	-	-	-	-	211	-	235.5
Steel Fibers	234	858	173	234	173	156	346	157
Fly Ash	-	-	-	-	-	-	-	-
Superplasticizer	40	44	38	40	38	30.7	76	31.4
Water	211	180	200	300	150	109	400	196.3

Compression Test



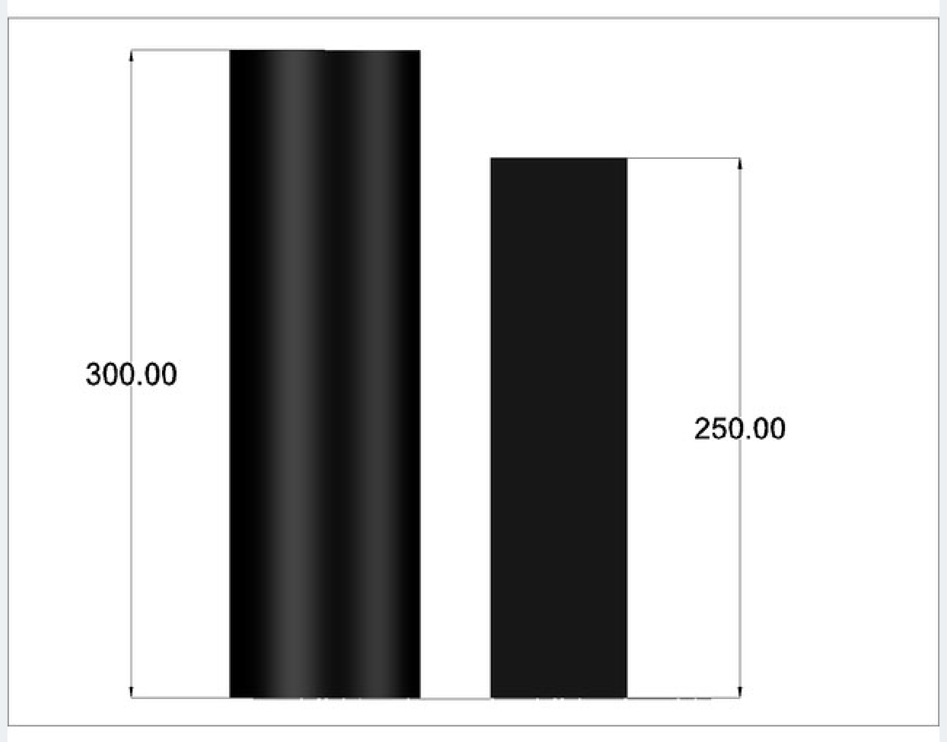
Compression Test Setup

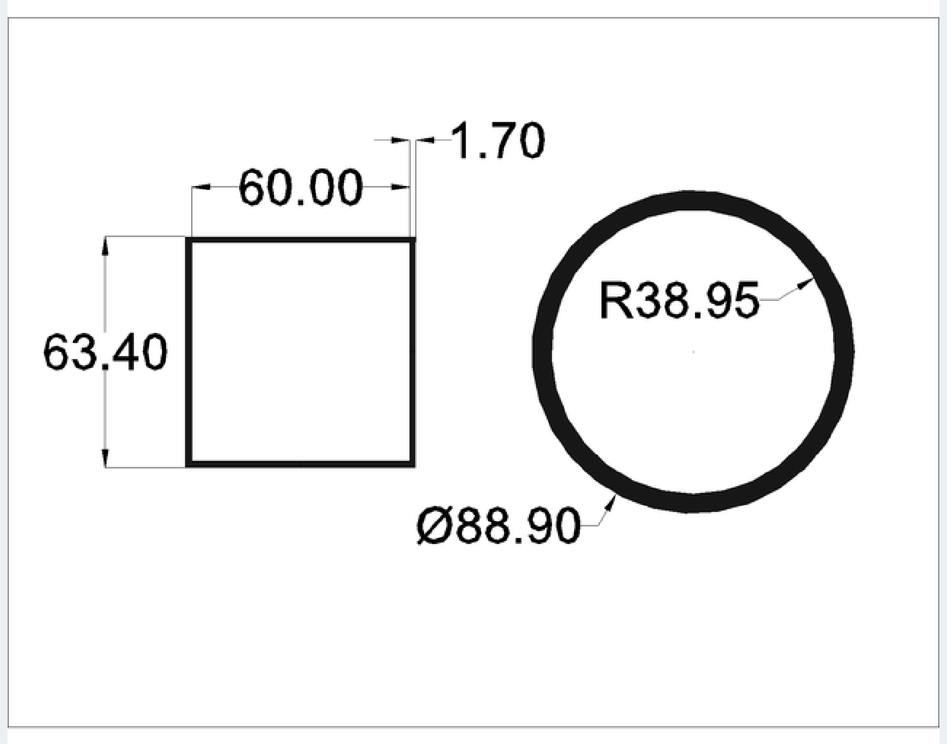
After curing for specific 3, 7, and 28 days, compressive test was done to ensure the compressive strength each samples

Steel Hollow

Steel Hollow Preparation

2 samples 300mm of circular steel hollow and 2 samples of 250mm square steel hollow was cut and prepared



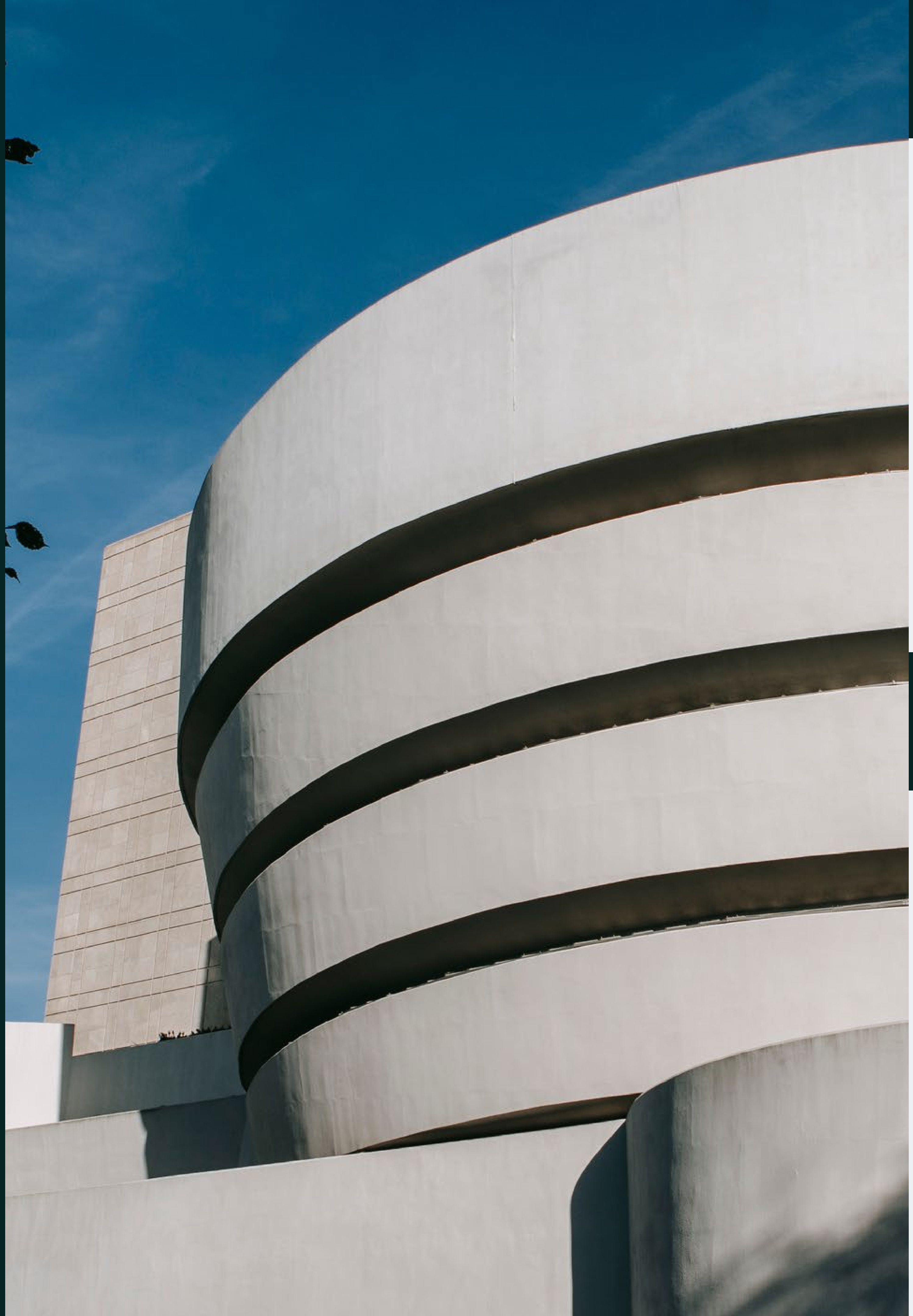


Push Out Test

Push Out Test

Universal Testing Machine of 200kN capacity was used to push the concrete core until it de-bonds with the steel

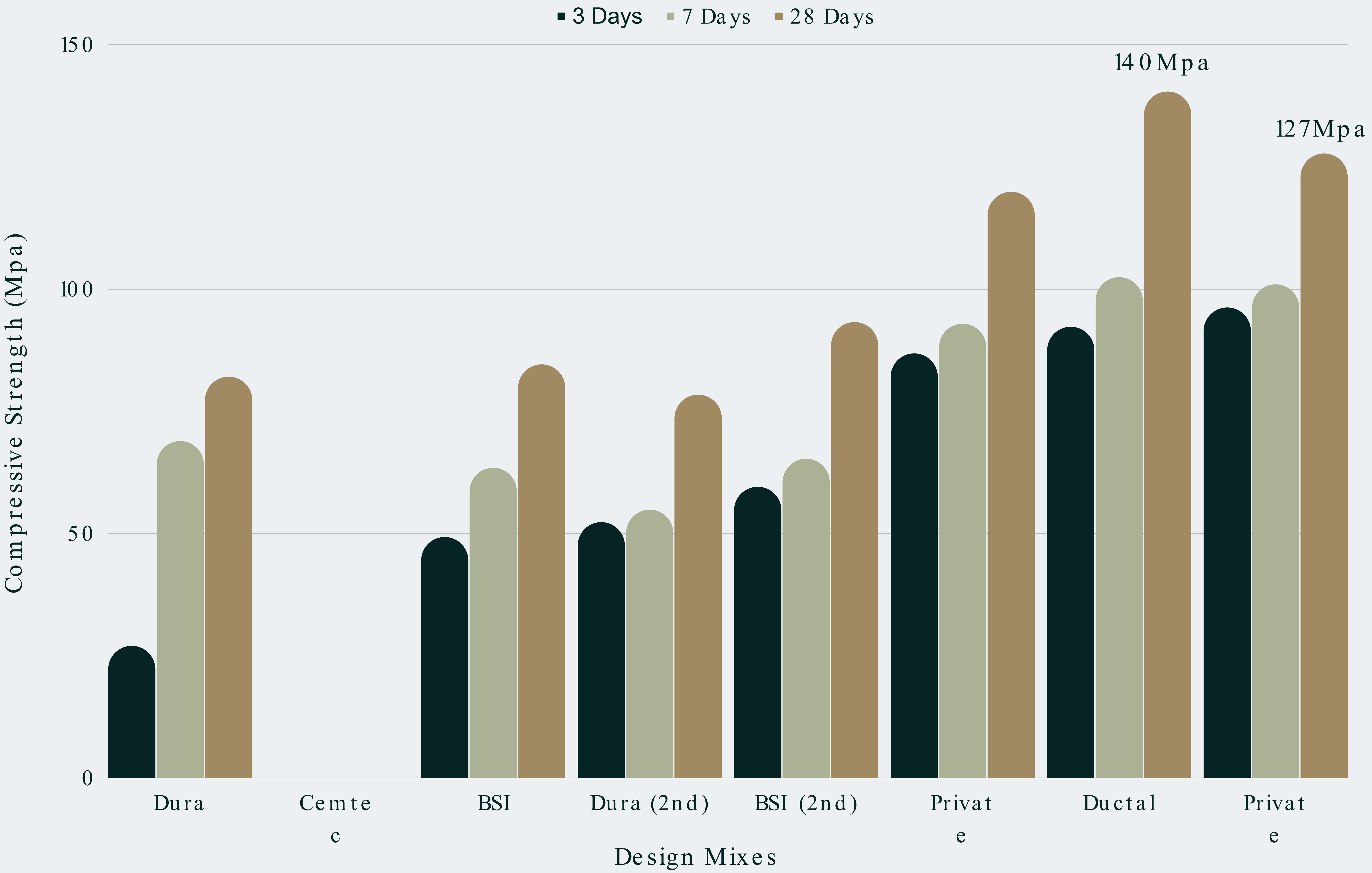
Results and Analysis



All together, 8 trial mixes was done to achieve the required compressive strength, greater than 120Mpa

4 samples of CFST with 2 different shapes were tested in push out.

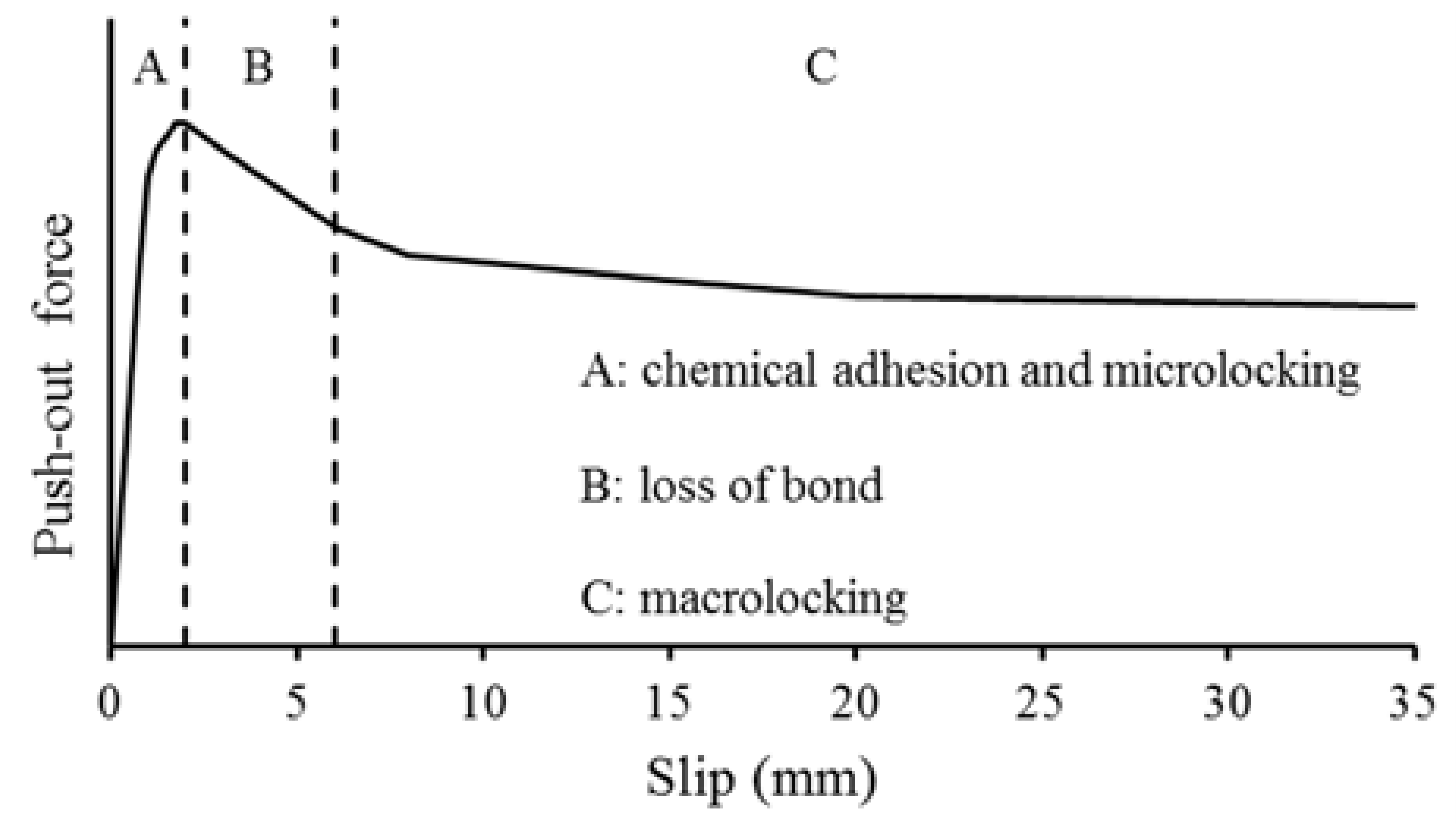
Compressive Strength



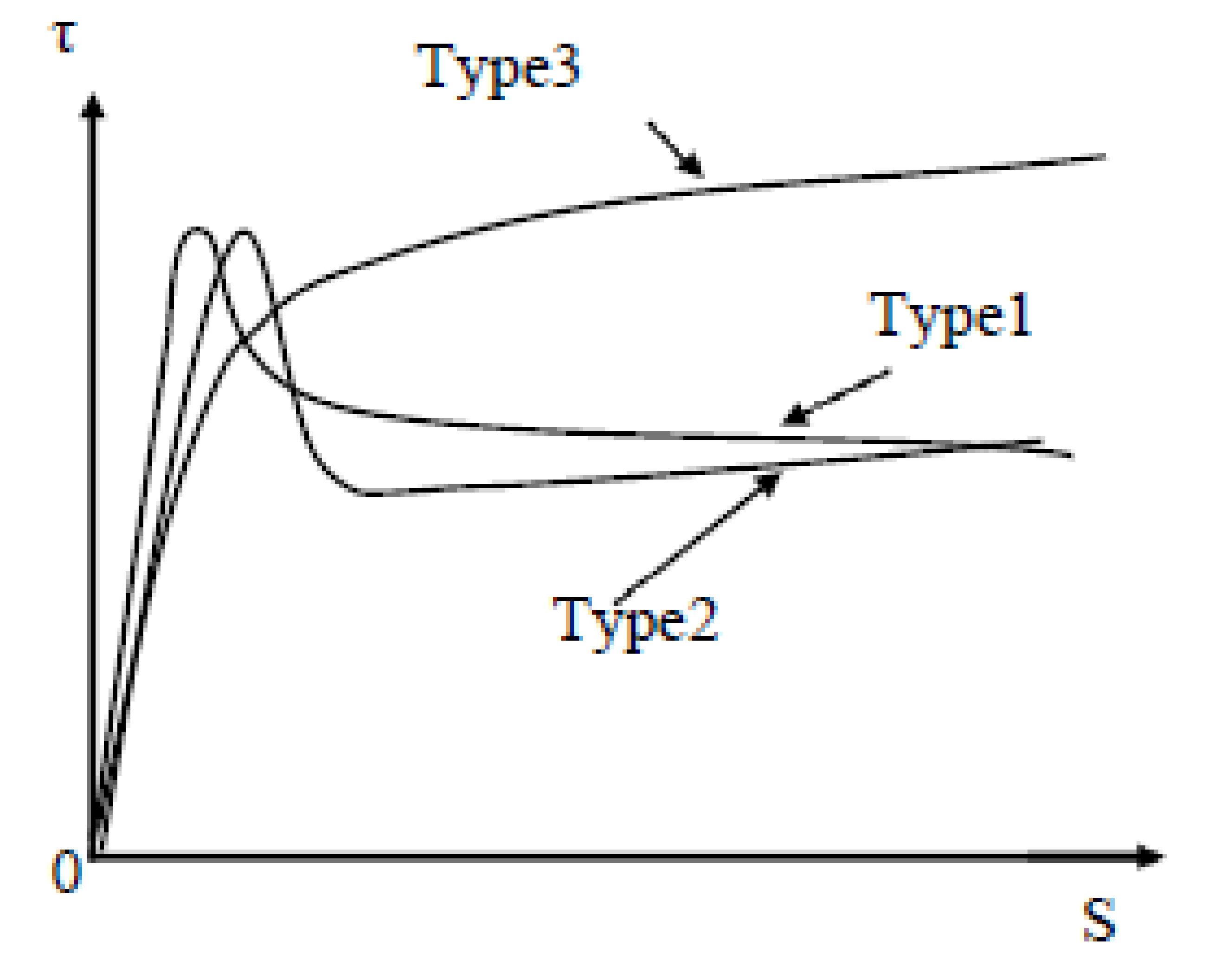
Compressive Strength

Design Mix	Sample	Manufactured Date	Testing Date	Age (Days)	Compressive Strength (Mpa)
Dura	1	17/8/2022	24/8/2022	7	68.86
	2		15/9/2022	28	82.02
Cemtec	3	17/8/2022	-	-	-
	4		-	-	-
BSI	5	29/8/2022	6/9/2022	7	63.40
	6		27/9/2022	28	84.53
Dura (2nd)	7	30/8/2022	7/9/2022	7	54.84
	8		28/9/2022	28	78.34
BSI (2nd)	9	13/9/2022	21/9/2022	7	65.24
	10		12/10/2022	28	93.20
Private Source	11	27/9/2022	5/10/2022	7	92.87
	12		26/10/2022	28	119.84
Ductal	13	17/10/2022	25/10/2022	7	102.41
	14		15/10/2022	28	140.35
Private Source	15	18/10/2022	26/10/2022	7	100.94
	16		15/11/2022	28	127.68

Idealized & Realistic Response of Push Out Test



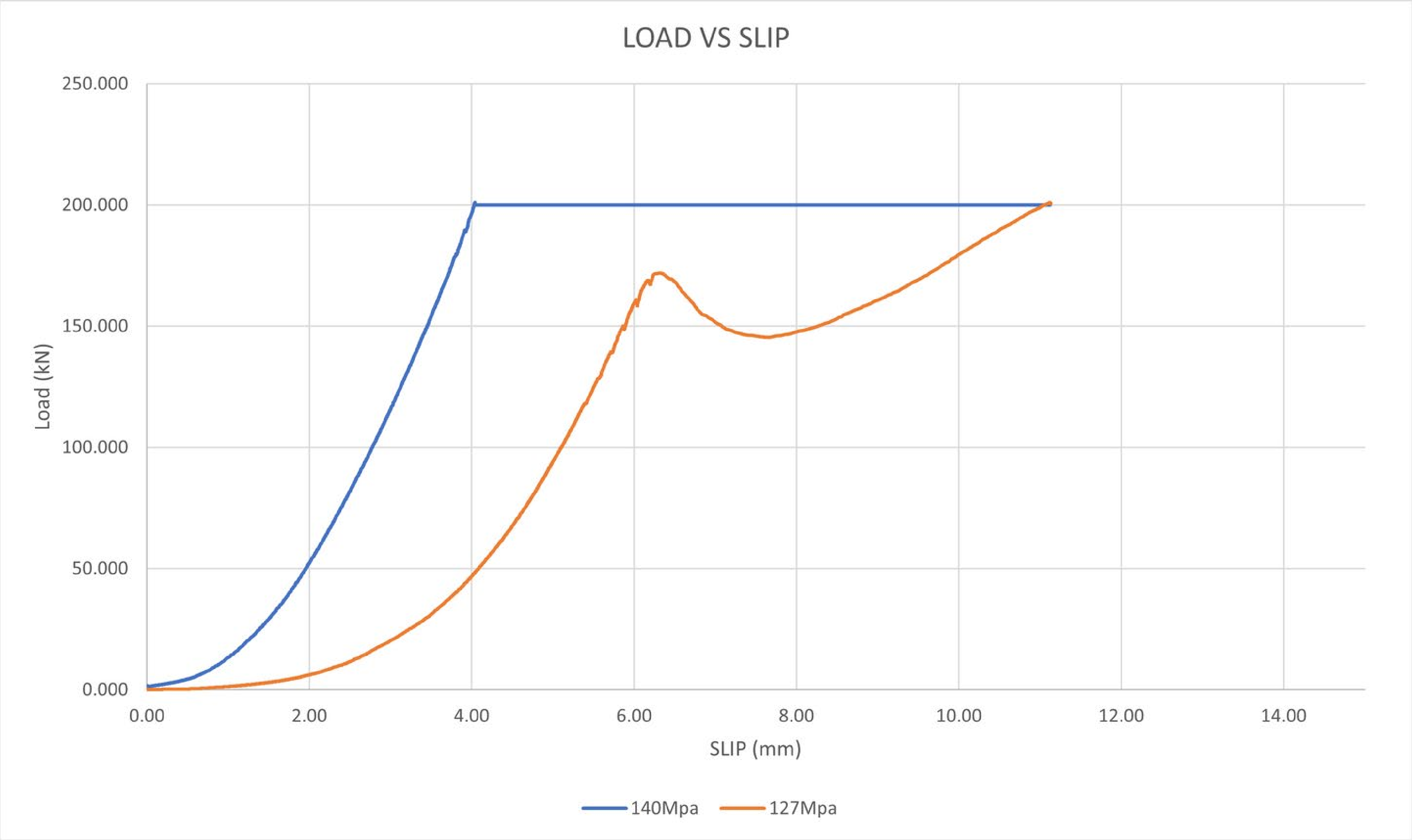
(Tao et al., 2011)



(Virdi and Dowling, 1975)

Push Out Test

Circular Cross Section



- At 200kN the sample with 140Mpa compressive strength had a slip of 4mm whereas the concrete with 127Mpa had a slip of 11mm.

- sample with 140Mpa similar to Type 3 load slip curve.
- Sample with 127Mpa similar to Type 2 load slip curve.

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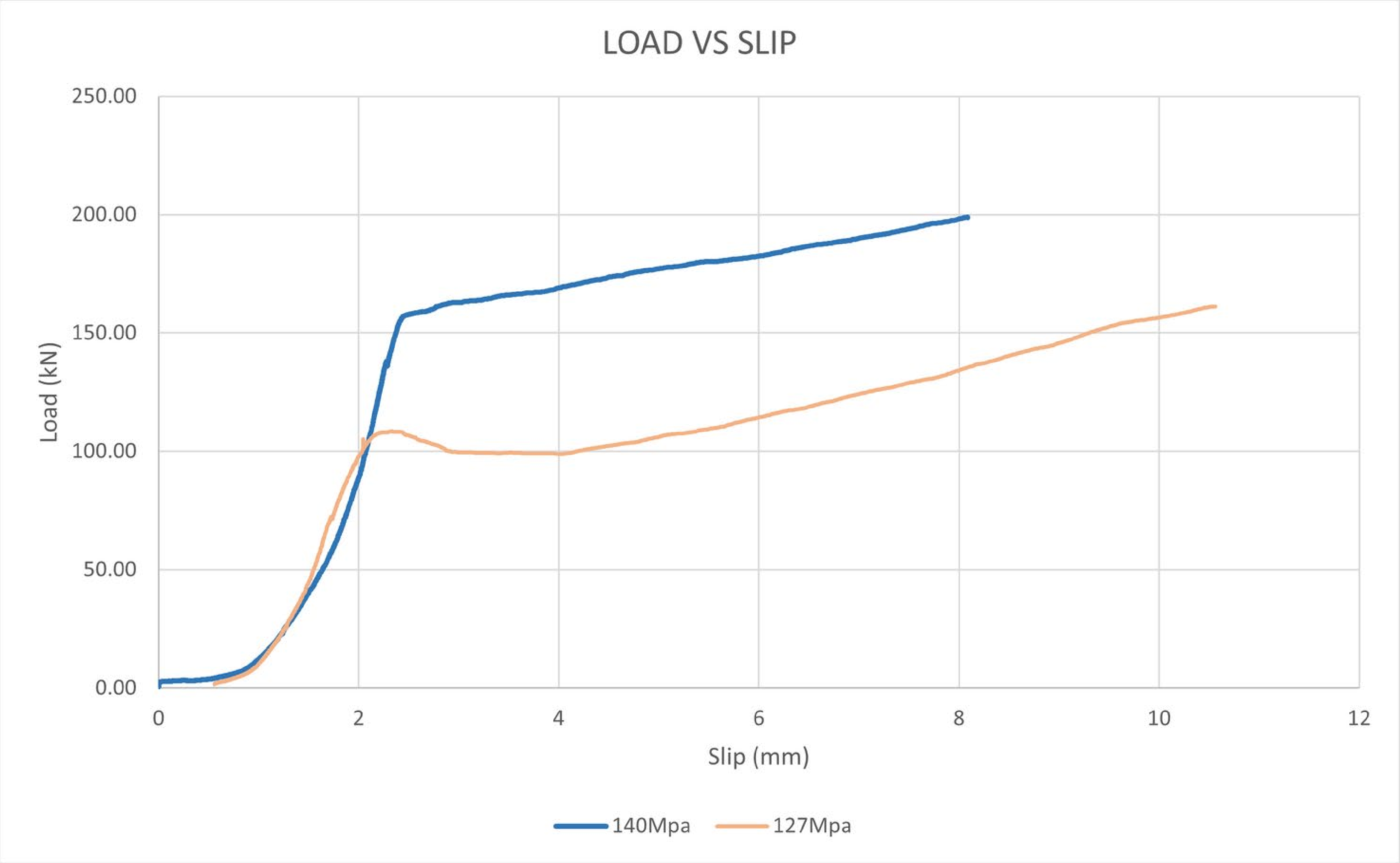
Push Out Test

Square Cross Section



- At 200kN the sample with 140Mpa compressive strength had a slip of 8mm whereas the concrete with 127Mpa had a slip of more than 10.3mm.
- sample with 140Mpa similar to Type 3 load slip curve.
- Sample with 127Mpa similar to Type 2 load slip curve.
- By comparison, 140Mpa has a better bonding strength compared to 127Mpa of compressive strength.

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Conclusion & Recommendation

The objective of this research is achieved with the results obtained from the tests which can conclude the significance of the compressive strength

Compressive Strength of the concrete core of CFST can significantly affect the bonding strength of the concrete steel.

Limitations of Tests

Current Push Out Test has limitations.
Impartial other types of forces, bending moment.
Load transfer from a element to another through plates or others.

Small Scale of Data

Too little comparison of samples due to various factors of time costs and resources.

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Thank you!

Do you have any questions?

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