ACIC

UNIVERSITY of BRADFORD

Faculty of Engineering & Informatics

FLEXURAL BEHAVIOR OF GEO-POLYMER CONCRETE T-BEAMS REINFORCED WITH HYBRID FRP/STEEL BARS

BY: MOHAMAD A. HASAN

THERESE. SHEEHAN

ASHRAF F. ASHOUR

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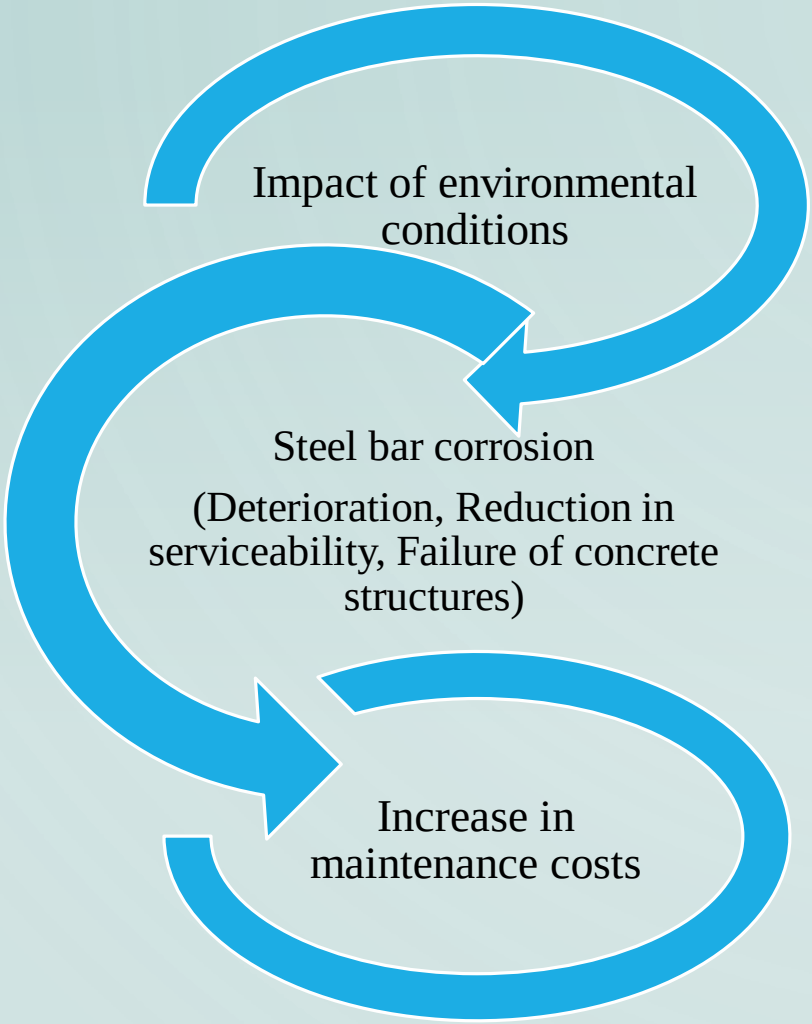
- Aims and Objectives.
- Research Significance.
- Analytical Model.
- Validation of the Analytical Modelling.
- Parametric study.
- Conclusions.

Why FRP Bars?


Impact of environmental conditions
Steel bar corrosion
(Deterioration, Reduction in serviceability, Failure of concrete structures)
Increase in maintenance costs

Application of FRP as internal reinforcement, Emaa Park Bridge deck panel with GFRP reinforcing bars (ACI 440.1R-15)

FRP RE-Bars in Concrete Structures

Lower Modulus of Elasticity

Decrease in the flexural stiffness after cracking

Large deformation under service conditions

Design is governed by the serviceability limit state

Linear-Elastic behavior up to rupture

A sudden failure with little or no ample warning

Why Hybrid (GFRP/Steel) Bars Structures?

	FRP BARS	STEEL BARS
Advantage	High tensile strength to weight ratio	Cheap price
	Corrosion resistance	Ductile behavior
	Electromagnetic transparency	
Disadvantage	Brittle behavior	The costly maintenance of structure members due to corrosion of steel bars
	High cost	
	Lower elastic modulus	

Why T-beam Structures?

- Since the beam is cast monolithically with the slab, the flange also takes up the compressive stresses.
- Better headroom, this is direct outcome of the first point since the depth of the beam can be considerably reduced.
- For larger spans, T beams are usually preferred rather than rectangular beam as the deflection is reduced to a good extent.
- T-beams structures such as highway overpasses have extra material added, where the web joins the flange to reduce the T-beam's vulnerability to shear stress.
- Concrete beams are often cast integrally with the slab, forming a much stronger T– shaped beam. A T-beam typically has a narrower web than rectangular beam.

Applications of Concrete T-section Beams

- Bridges
- Highway overpasses
- Buildings
- Parking garages

Applications of Concrete T-Section Beams

Why Geo-polymer Concrete.

- Manufacturing OPC is very polluting. therefore, a need to find substitutes for OPC that will act as binding agents but emit less CO2.
- GPC is sustainable material and a green alternative to the ordinary Portland cement (OPC) concrete.
- GPC has a number of positive characteristics offered by geopolymers. They include rapidly developed mechanical strength, resistance to fire, resistance to acid.
- As the demand for the rehabilitation of existing RC structures and the construction of new infrastructure increases. Pointed out the benefit of a cost reduction of between 10% and 30% when fly ash GPC replaces OPC.

➢Aim and Objectives

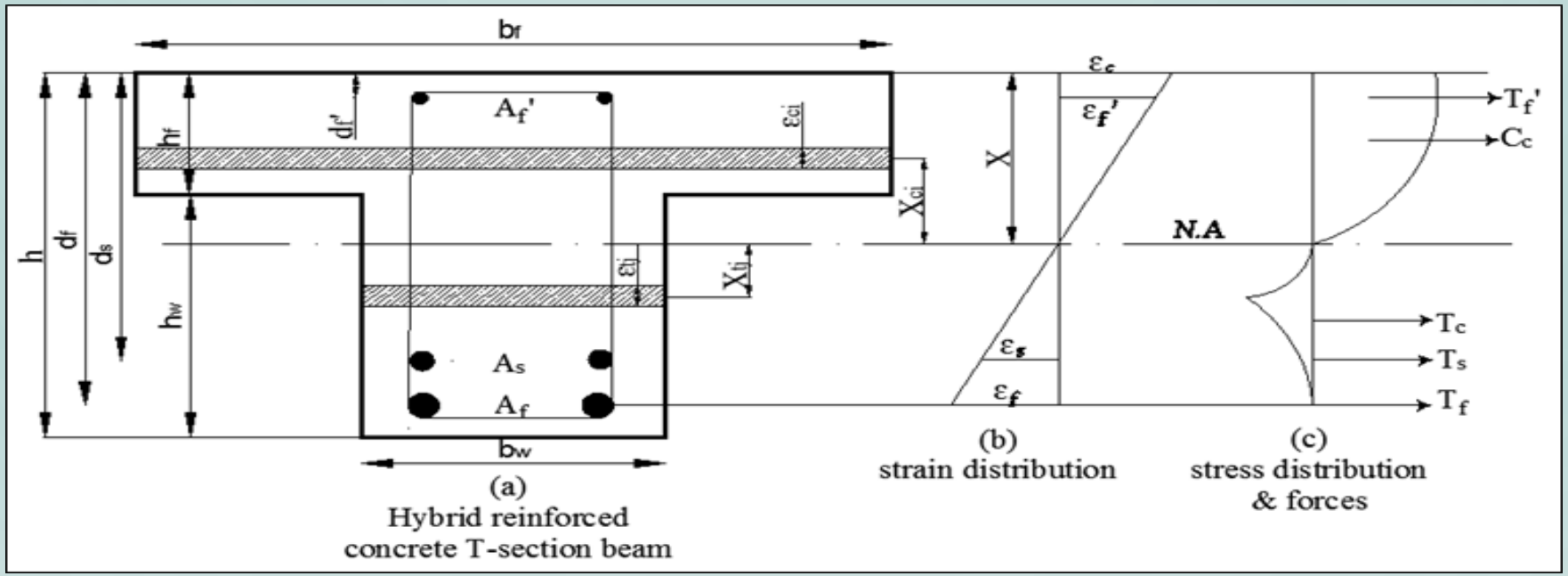
- To conduct experimental test to study the structural behaviour of T-sections beams reinforced with Hybrid (GFRP/steel) and pure GFRP beams with GPC and OPC.
- To develop an analytical technique for predicting the behaviour of T-section simply supported GPC and OPC beams reinforced with GFRP and hybrid reinforcement.
- To investigate the applicability of the current design provisions versus the experimental trial results GPC to evaluate the deflections and moment capacity of GFRP reinforced concrete flanged beams.

Research Significance

- The researchers have focused mainly on simply-supported beams with rectangular shapes.
- In most structural applications, RC beams and slabs are cast in a monolithic pour. As a result, the slab serves as the top flange of the beams which forms a T-shape member.
- GPC is sustainable material and a green alternative to the ordinary Portland cement (OPC) concrete due to the utilisation of the waste material and no calcination process involved in the production of its binder materials.

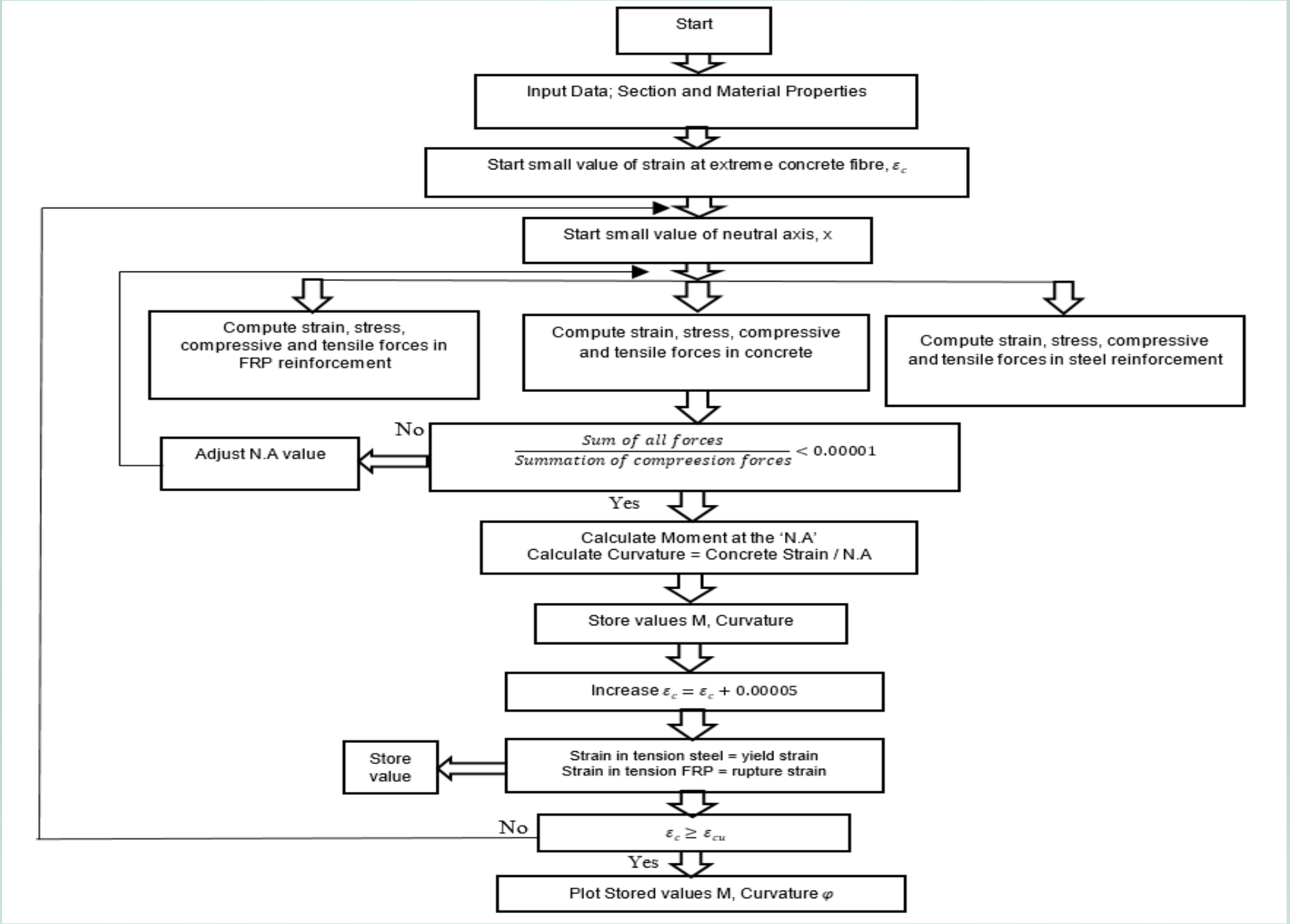
Analytical Model

- The first part of the programme was assigned to calculating the moment-curvature relationship of T sections reinforced with steel, FRP, and hybrid systems comprising both FRP and steel reinforcement.
- The numerical calculation required to estimate the moment-curvature relationship for the T concrete cross-section reinforced with steel, FRP and hybrid FRP/Steel that is divided into a number of segments, n, is presented.



Strain and stress distribution in a reinforced section

Flowchart diagram of the sectional analysis process



Validation of The Analytical Modelling Program Against Experimental Results

- T-SECTION REINFORCED WITH FRP BARS

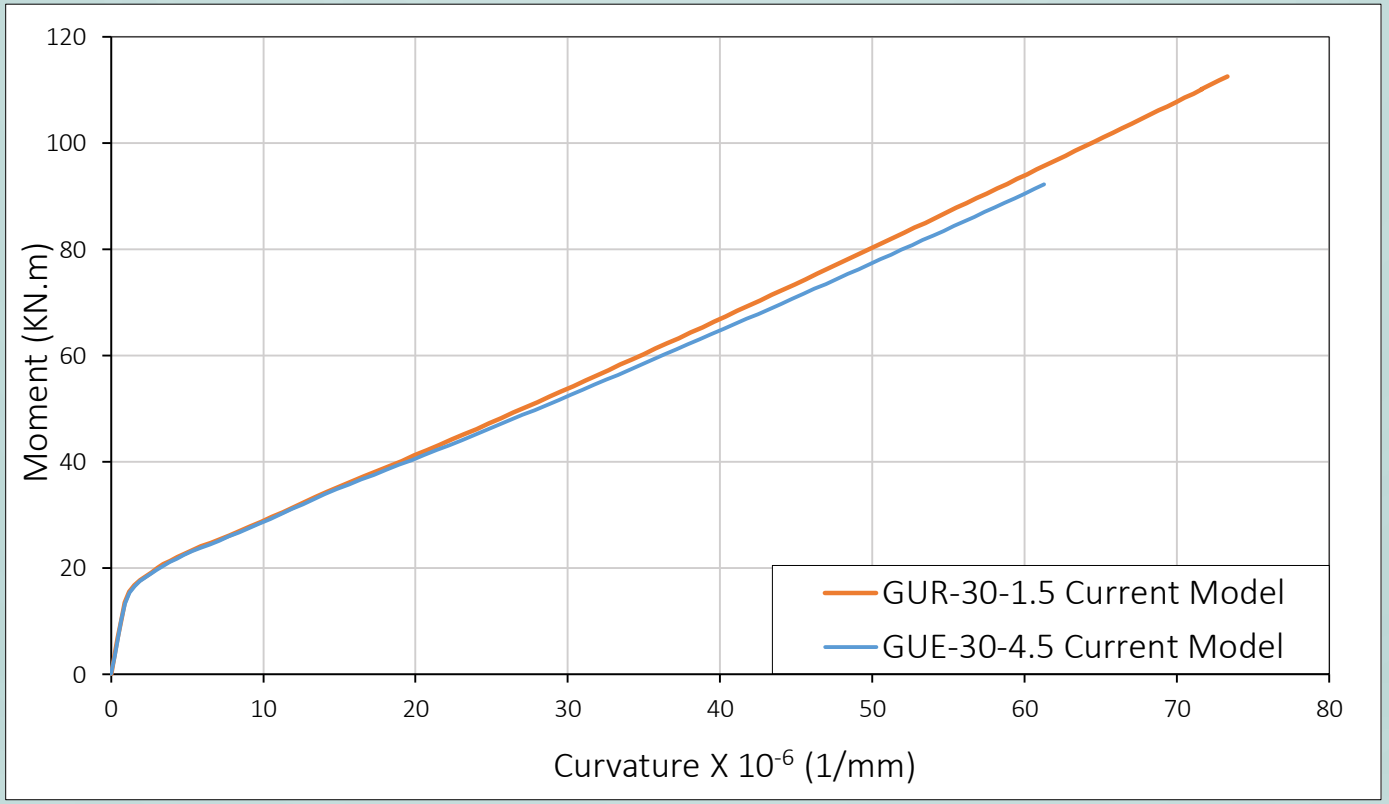


Figure 9. Compare between experimental and predicted moment-curvature relationships of specimen GUR-30-4.5.

❖ T-SECTION REINFORCED WITH HYBRID FRP/STEEL BARS

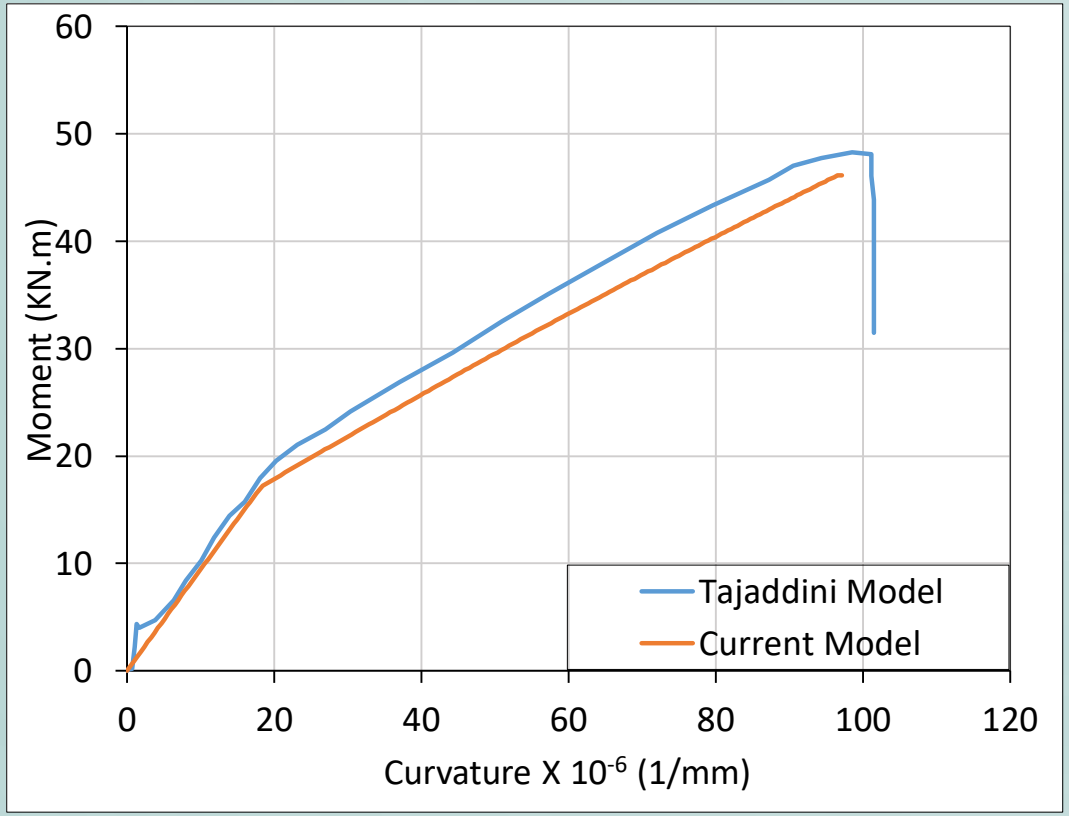


Figure 10. Compare between experimental and predicted moment-curvature relationships of specimen T2.

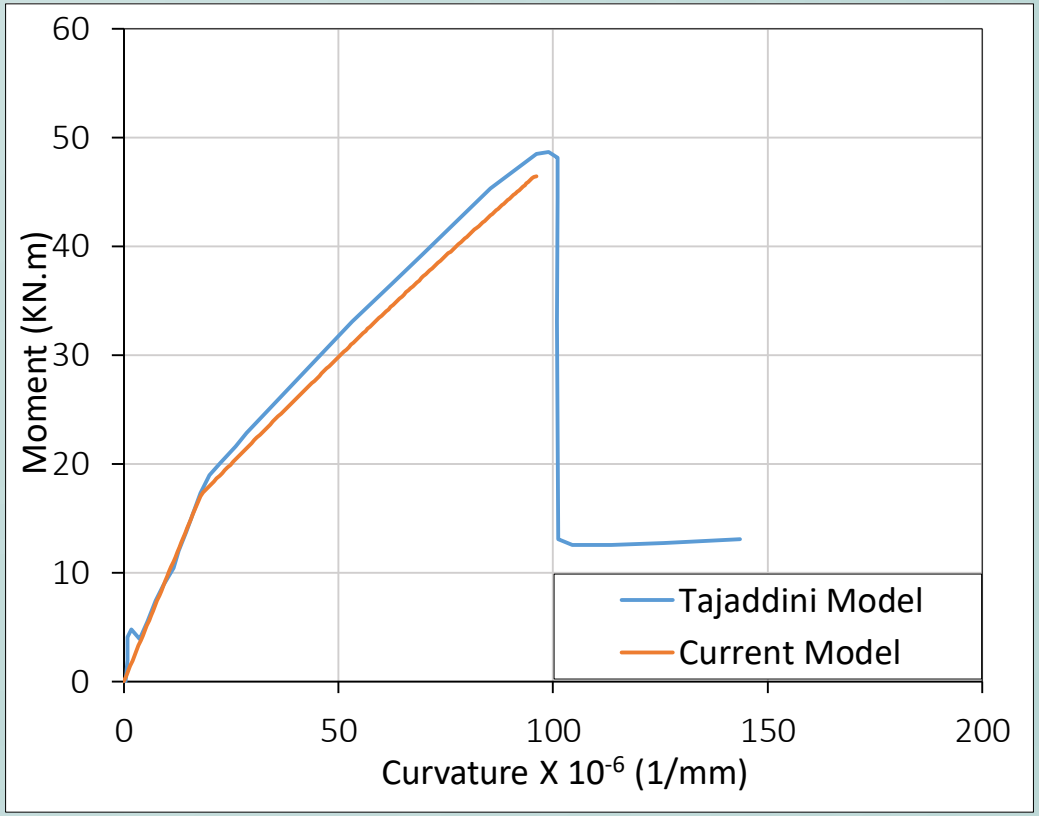
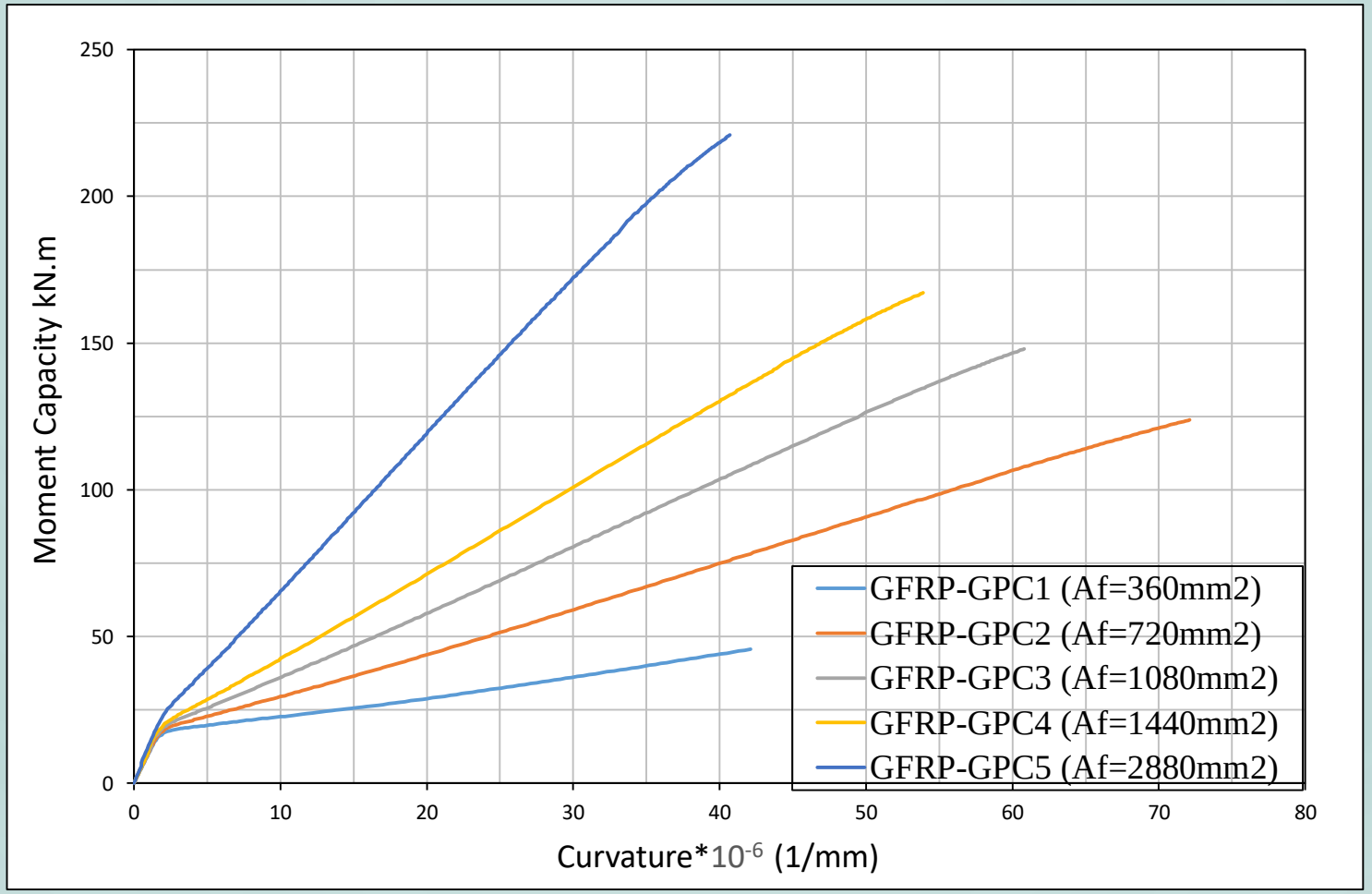


Figure 11. Compare between experimental and predicted moment-curvature relationships of specimen T5.

Parametric Study

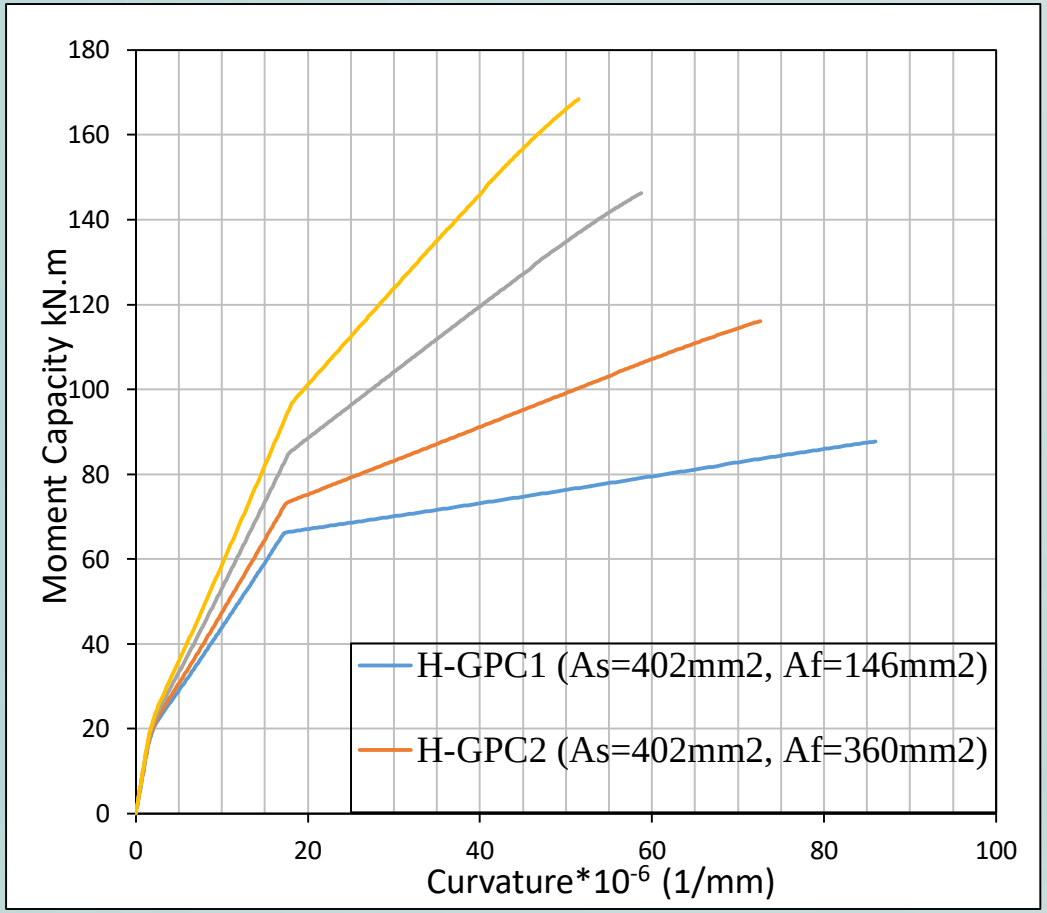
- Effect of Tensile Reinforcement Ratio.
- Effect of FRP Reinforcement Type.
- Effect of the Concrete Compressive Strength.
- Effect of the Compressive Reinforcement Ratio.
- Effect of the Position of the Tensile Steel Reinforcement.
- Effect of Flange Width.
- Effect of Flange Thickness.
- Effect of Concrete type.

Effect of Tensile Reinforcement Ratio

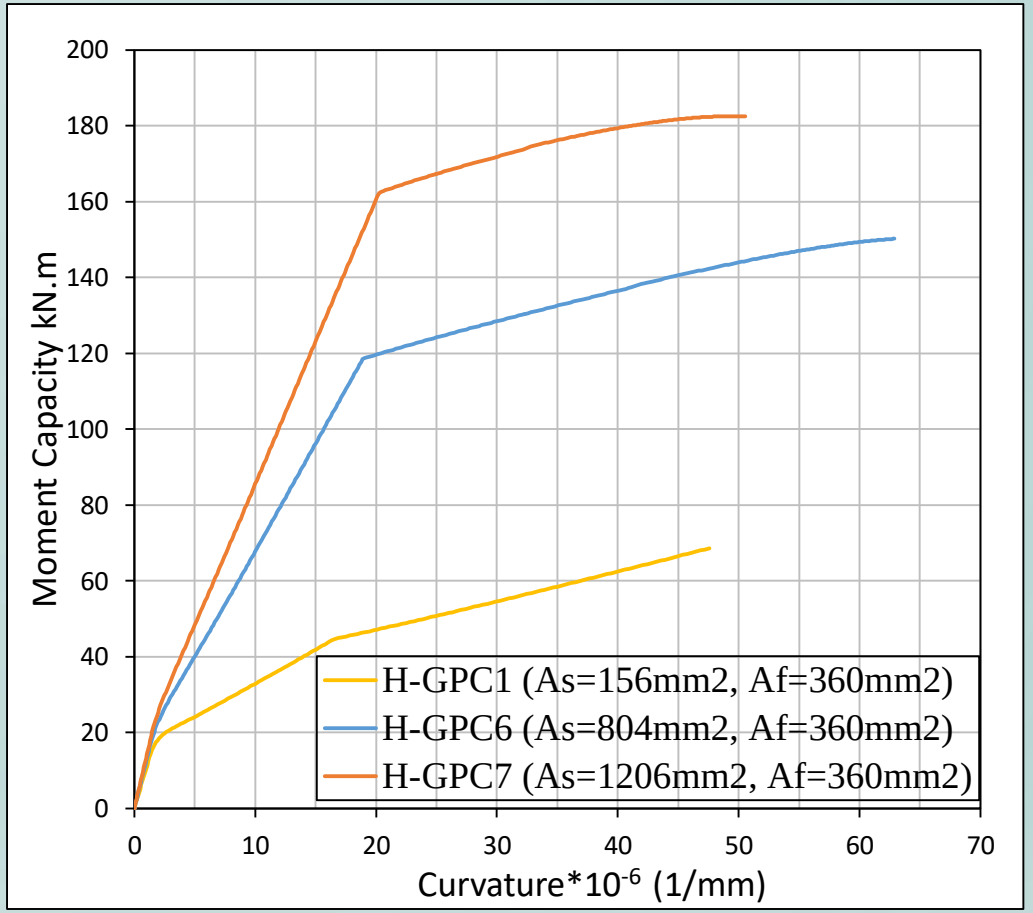


Moment Capacity vs. Curvature for FRP beams with different FRP tensile reinforcement ratio.

Effect of Tensile Reinforcement Ratio

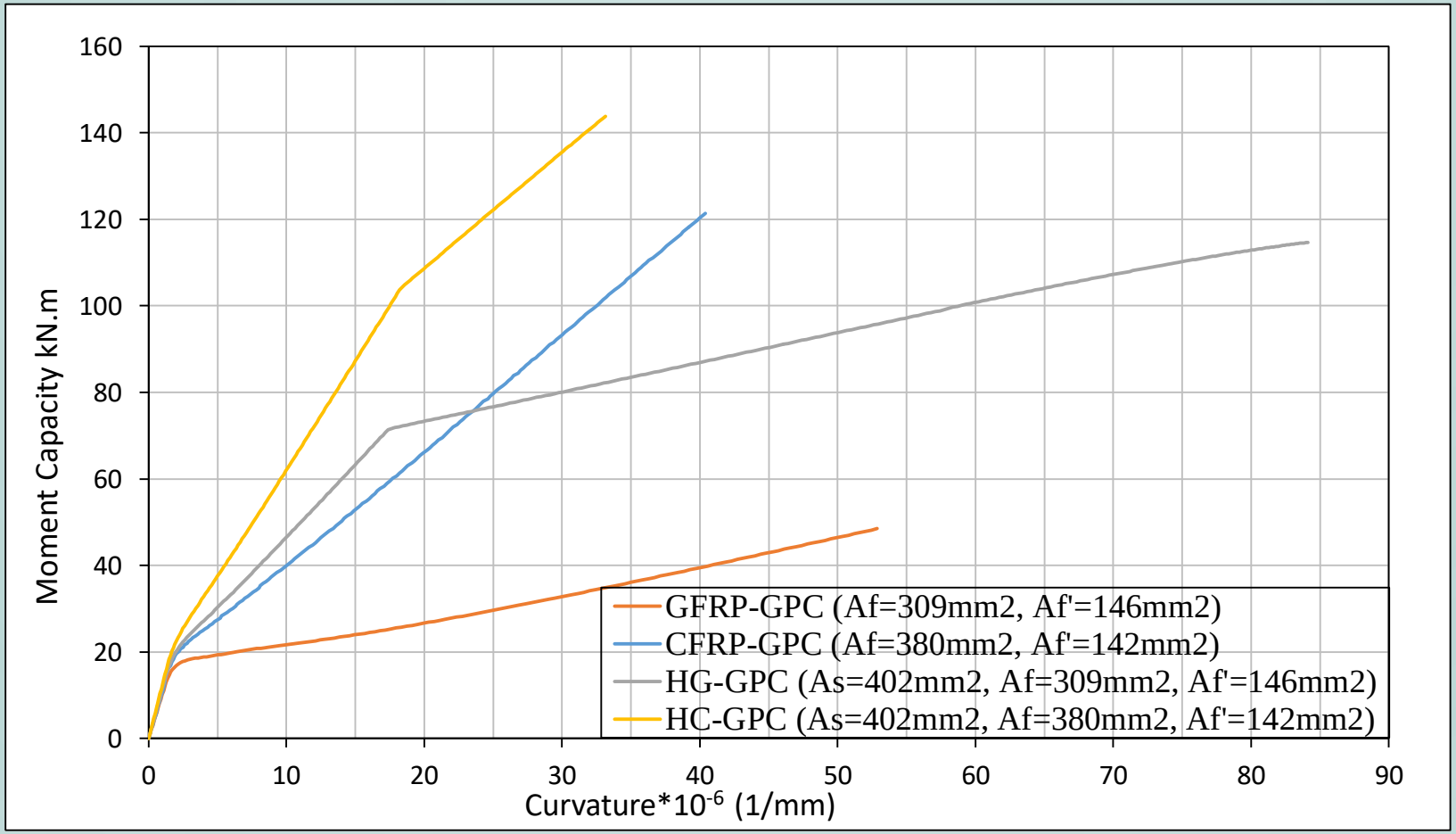


Moment Capacity vs. Curvature for Hybrid beams with different FRP tensile reinforcement ratio and same steel amount.



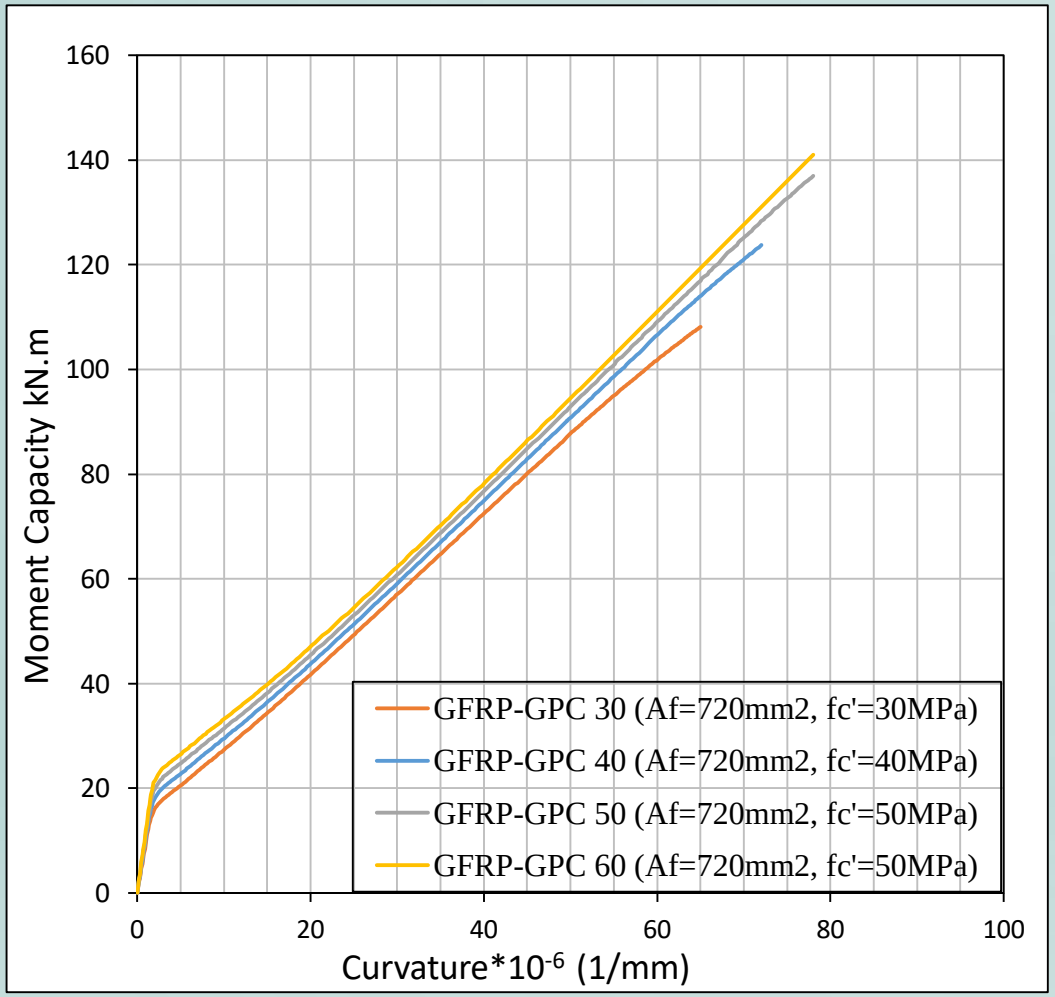
Moment Capacity vs. Curvature for Hybrid beams with different steel tensile reinforcement ratio and same FRP amount.

Effect of FRP Reinforcement Type

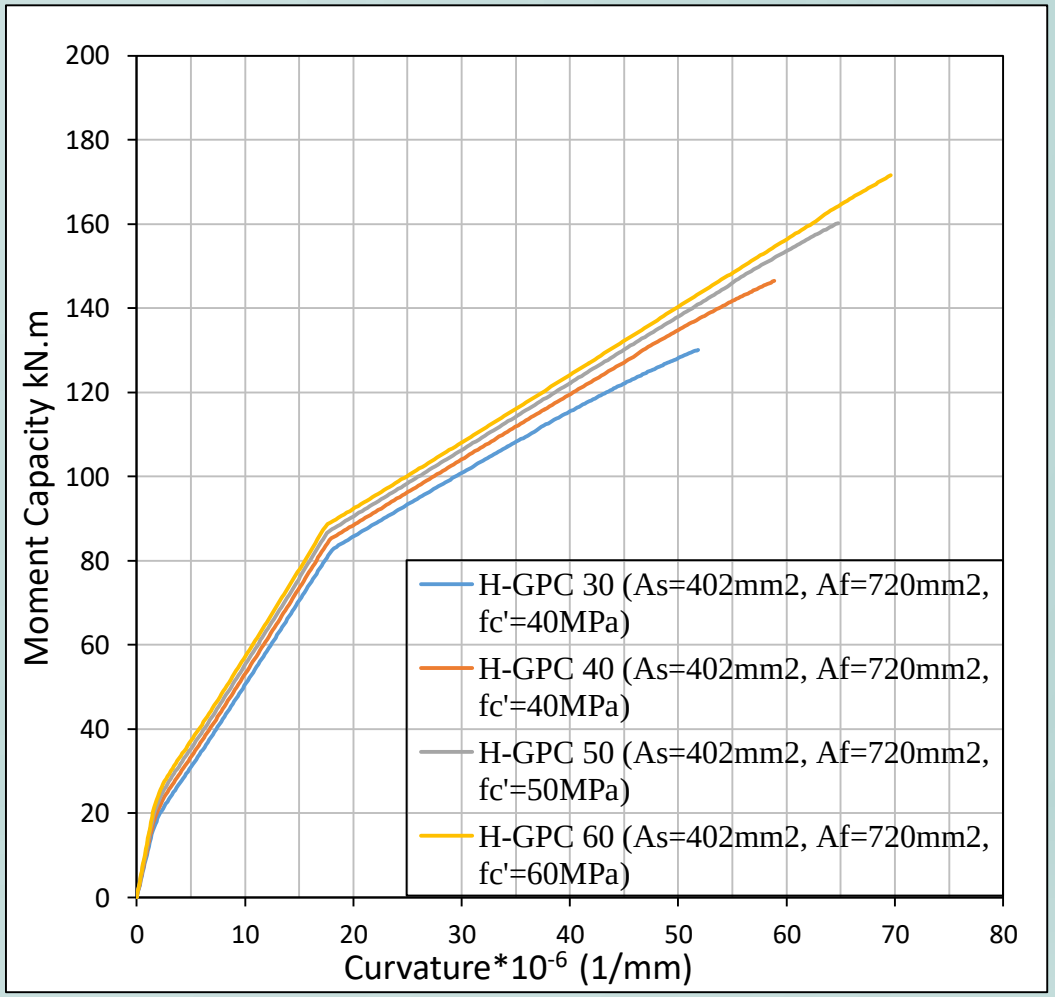


Moment Capacity vs. Curvature for different type of FRP & Hybrid tensile reinforcement ratio.

Effect of The Concrete Compressive Strength

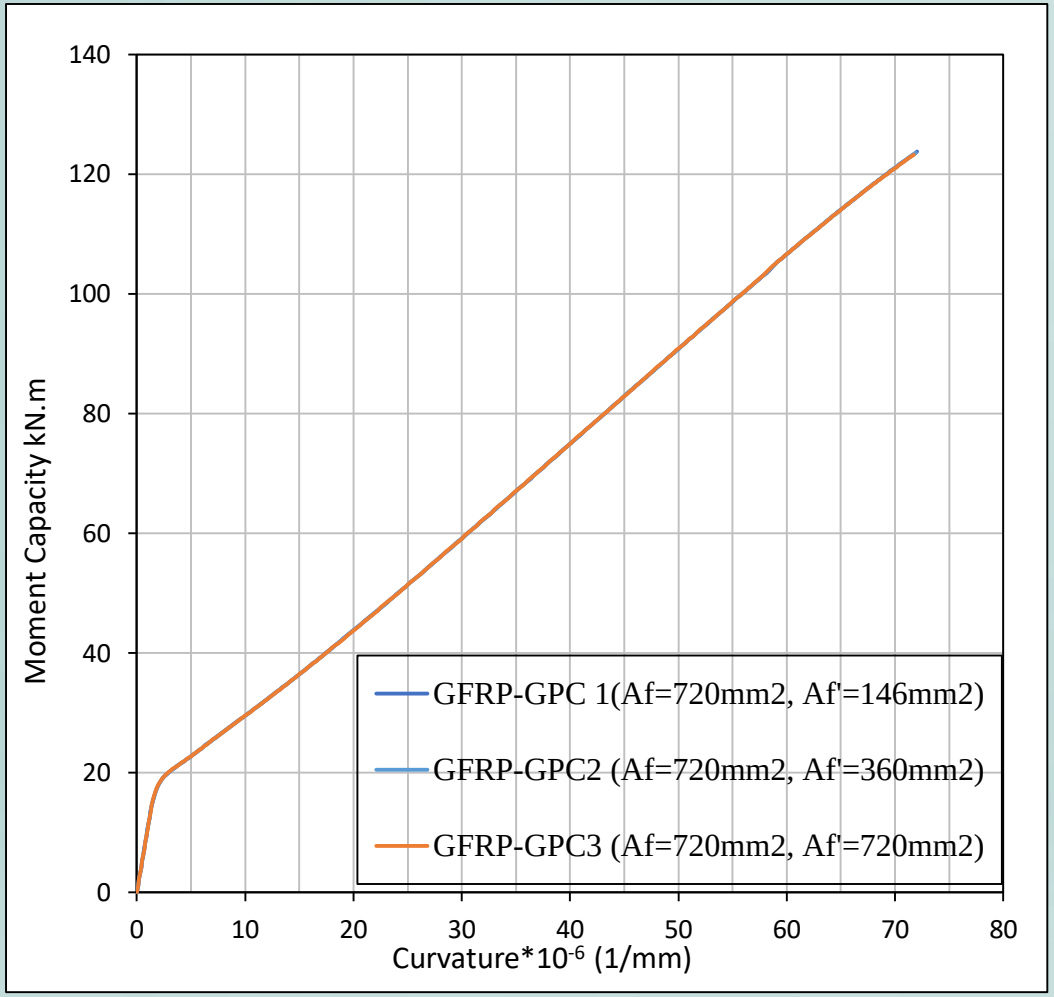


Moment Capacity vs. Curvature for FRP beams with different compressive strength.

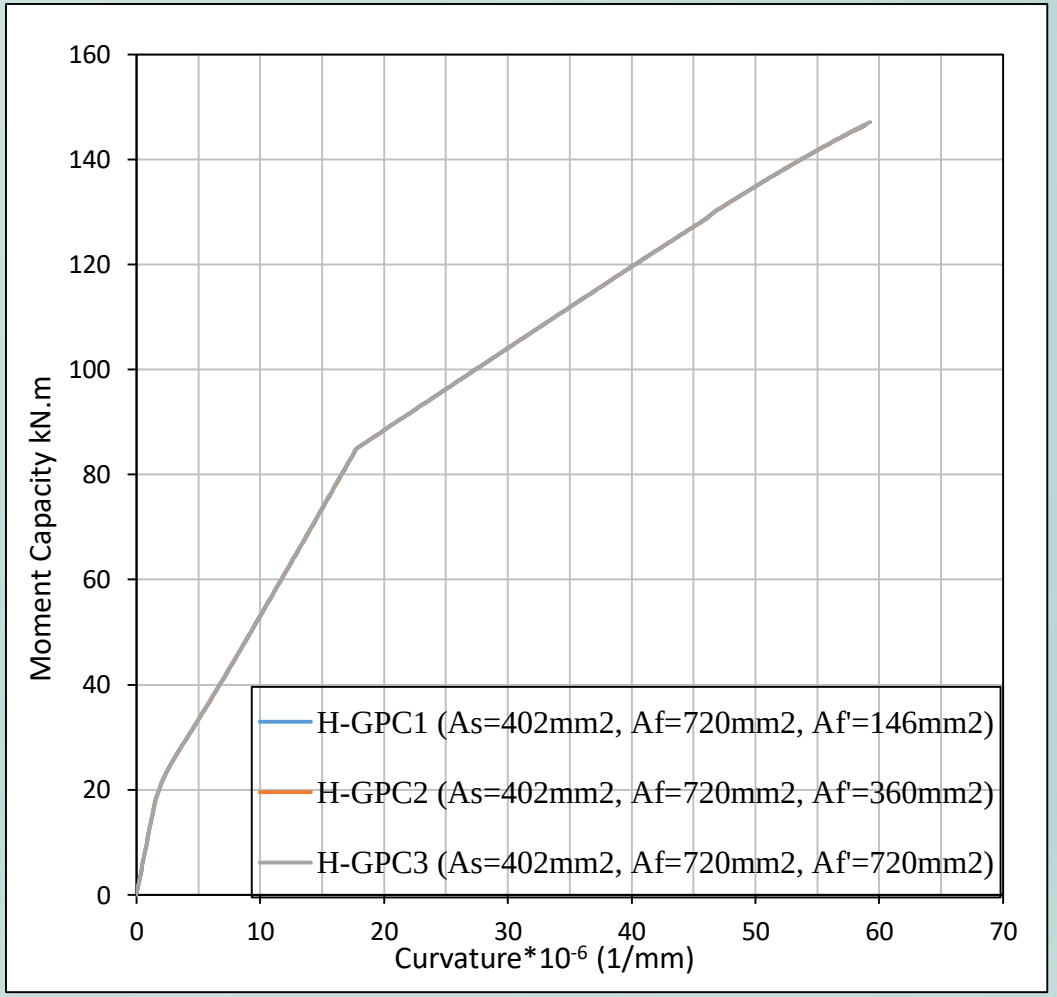


Moment Capacity vs. Curvature for Hybrid beams with different compressive strength.

Effect of The Compressive Reinforcement Ratio

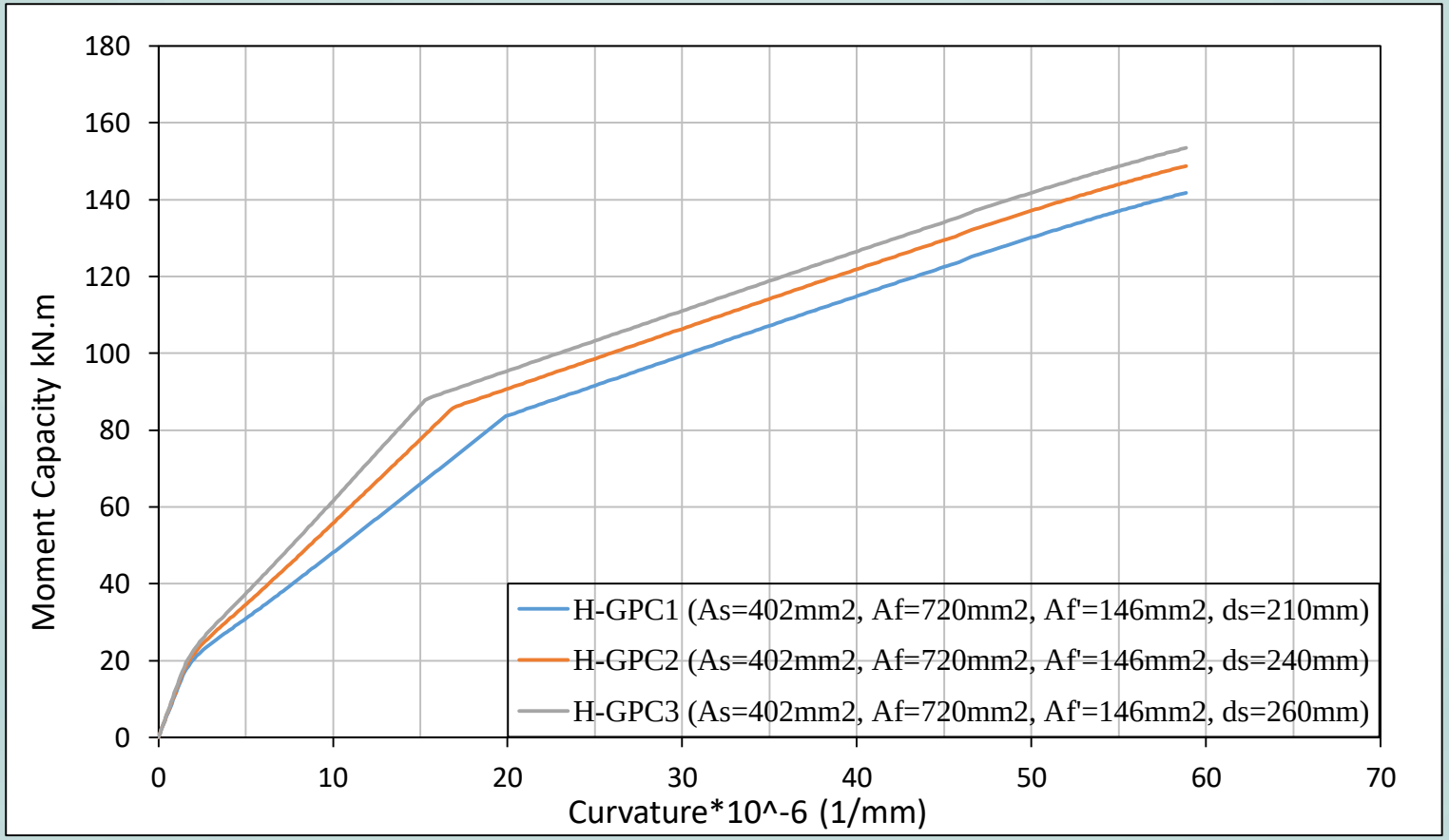


Moment Capacity vs. Curvature for FRP beams with different compressive reinforcement ratio.



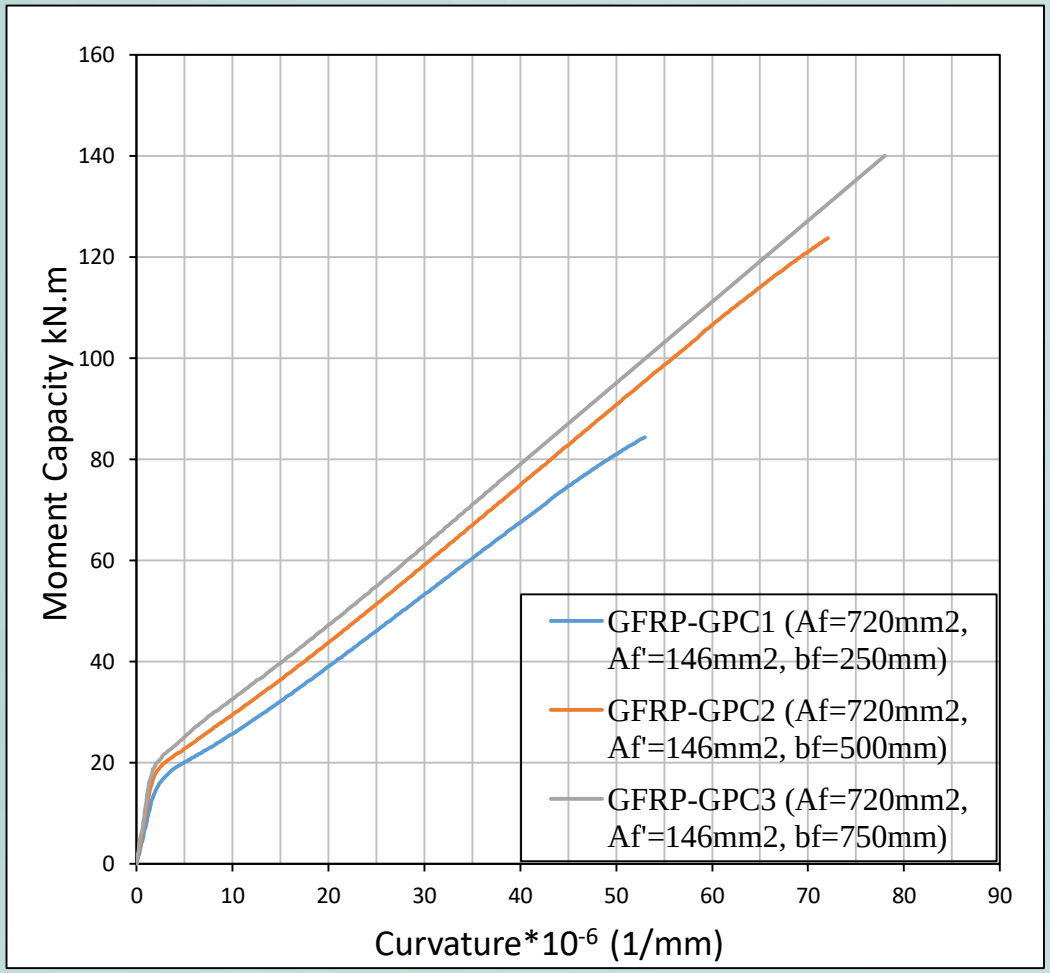
Moment Capacity vs. Curvature for Hybrid beams with different compressive reinforcement ratio.

Effect of The Position Of The Tensile Steel Reinforcement

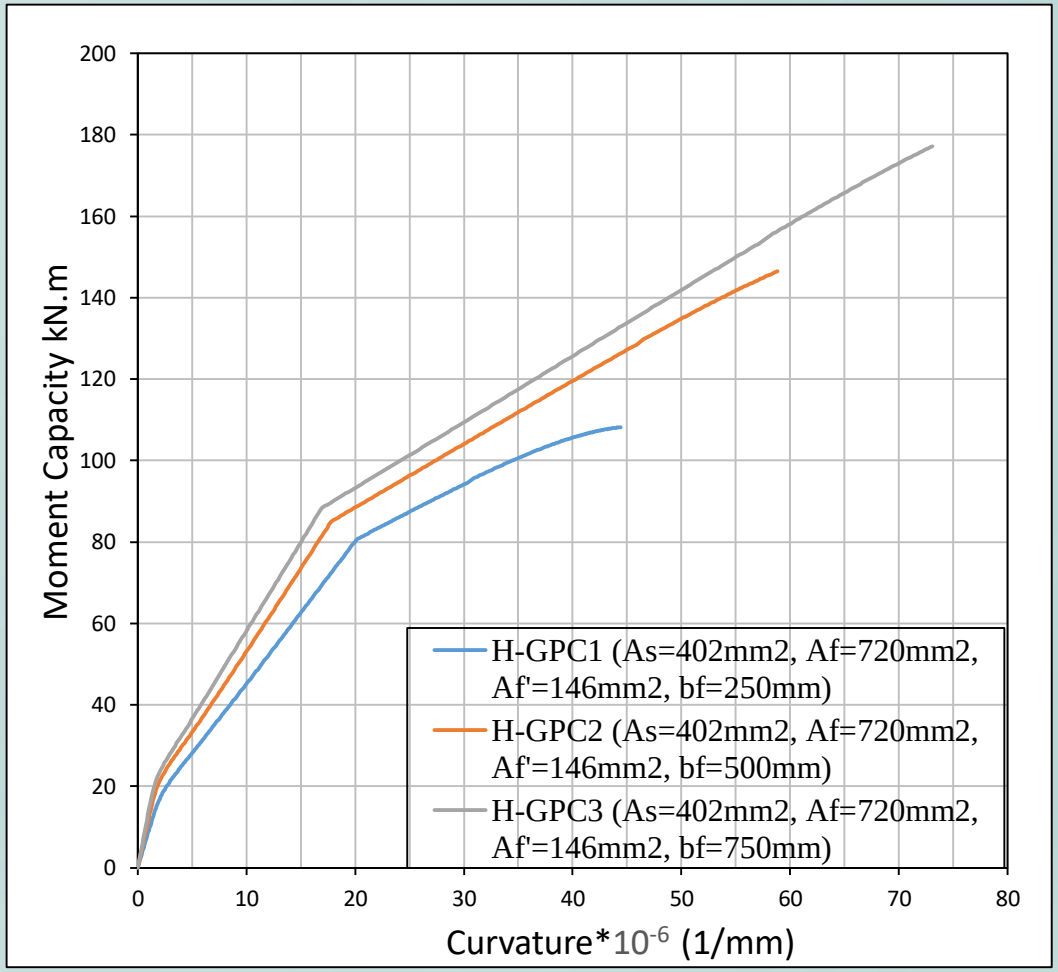


Moment Capacity vs. Curvature for FRP beams with different compressive reinforcement ratio.

Effect of Flange Width.

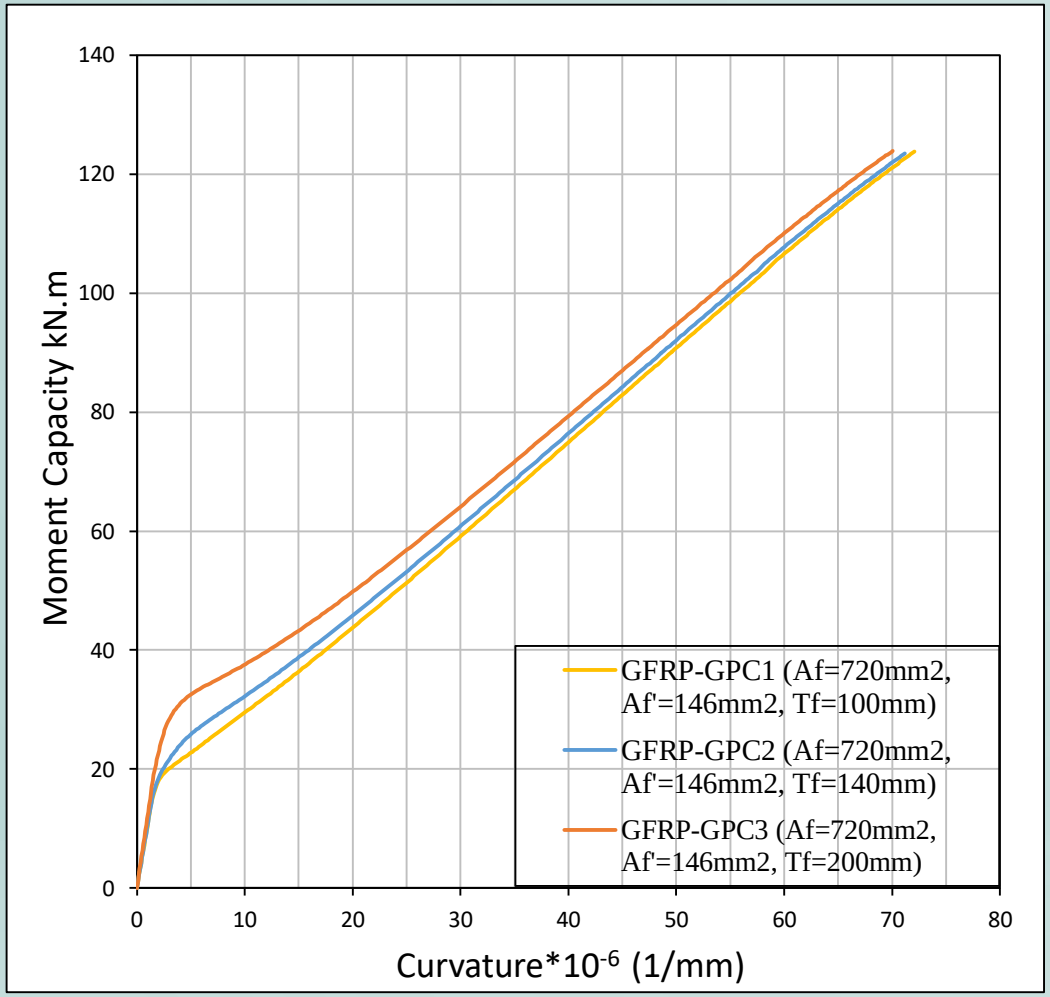


Moment Capacity vs. Curvature for FRP beams with different flange width.

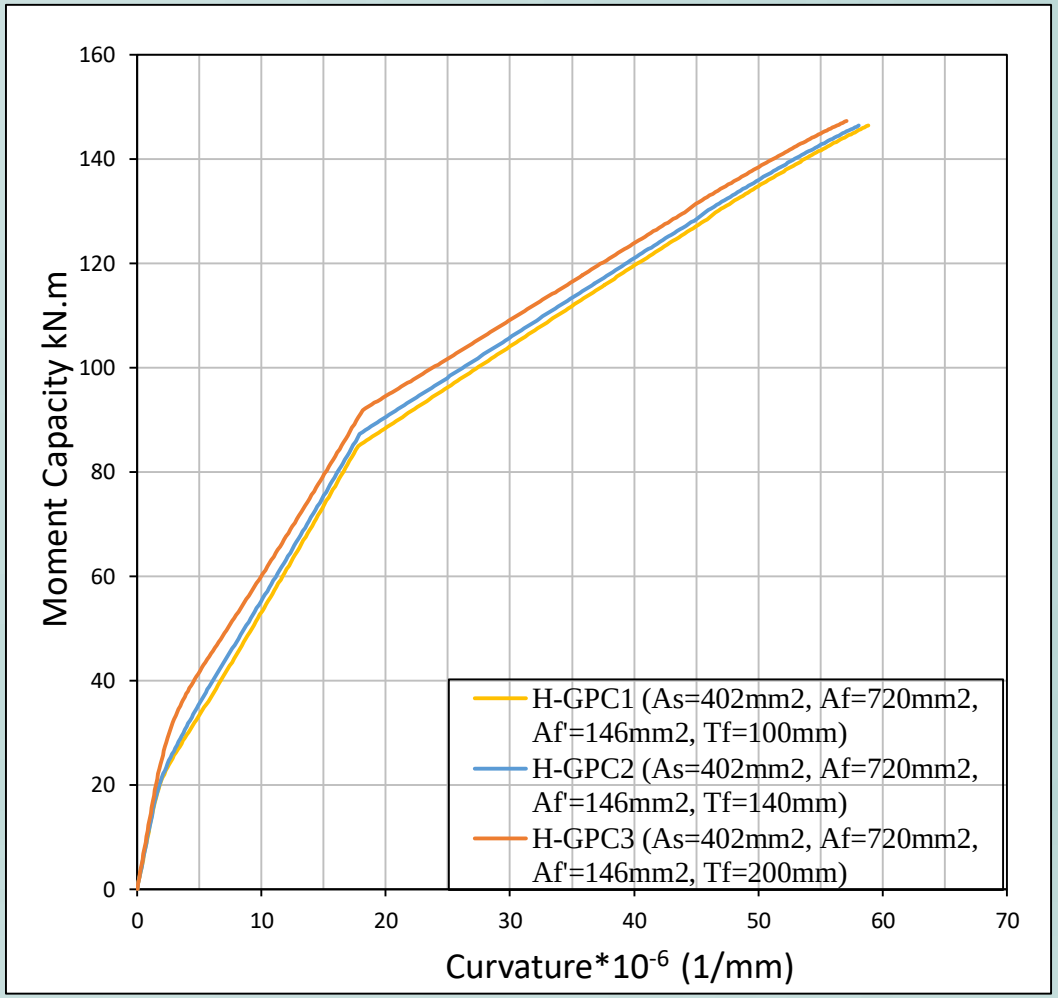


Moment Capacity vs. Curvature for Hybrid beams with different flange width.

Effect of Flange Thickness.

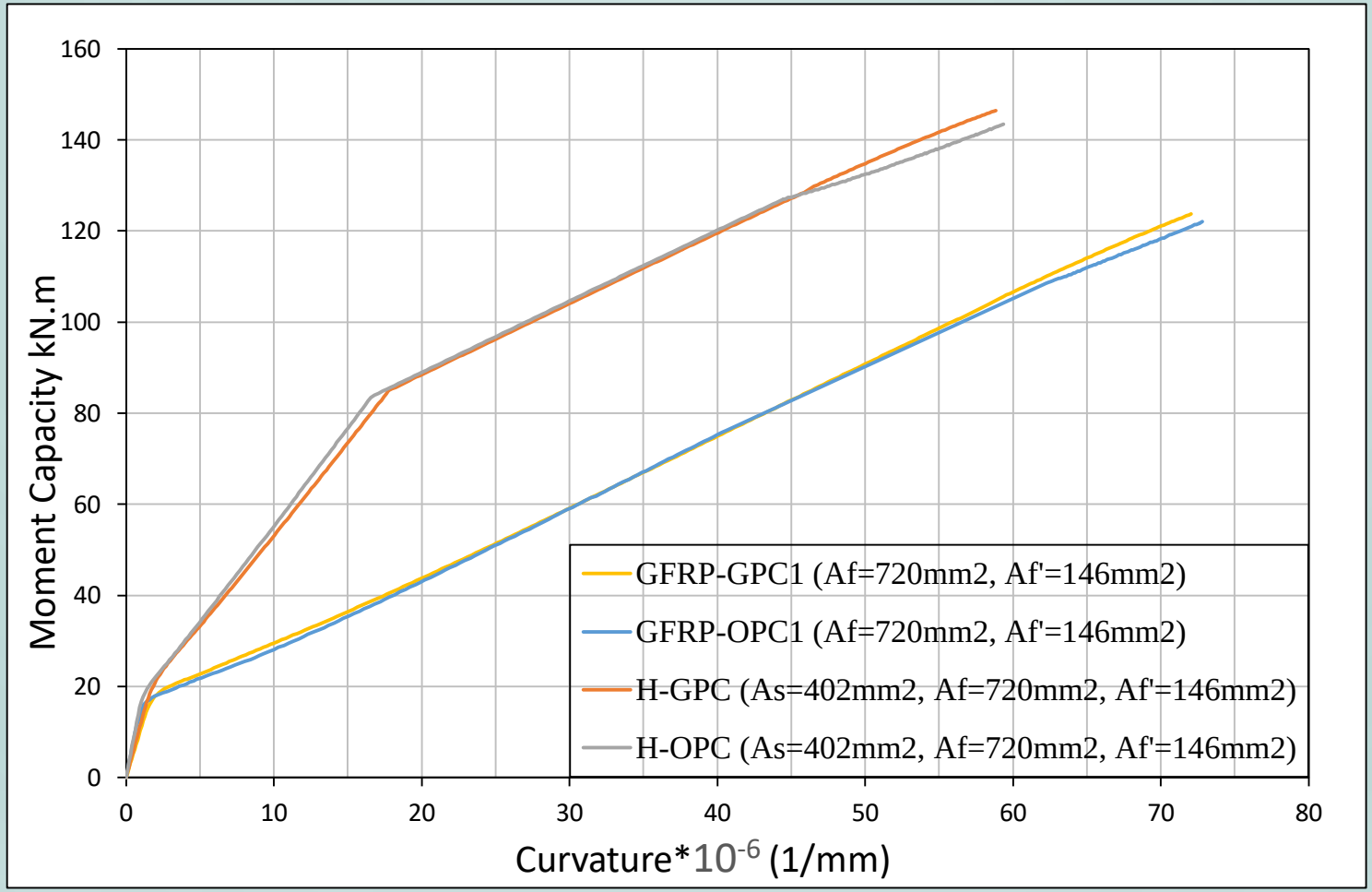


Moment Capacity vs. Curvature for FRP beams with different flange thickness



Moment Capacity vs. Curvature for Hybrid beams with different flange thickness.

Effect of Concrete Type



Moment Capacity vs. Curvature for FRP & Hybrid beams with different concrete type.

Conclusions

- In both FRP and hybrid, the technique has a great deal of congruence which is clearly shown in figures.
- Comparisons between experimental and predicted moment-curvature curves of FRP and hybrid FRP/steel T-section reinforced (GPC, OPCC) concrete showed reasonable degrees of agreement.
- The parametric study increased the validity of the investigation of the work of the technique through the results presented.
- The participation of steel reinforcement in hybrid sections resulted in improvements in both; ductility and stiffness.
- The trend of the behaviour of GPC was found almost similar to that reported in OPCC.
- The mode of failure, type of FRP materials, reinforcement ratio, the width of the flange and the effect of vertical reinforcement on the web flange interaction are parameters that needed to be investigated.

Thank you for Listening