بسم الله الرحمن الرحيم

KINGDOM OF SAUDI ARABIA
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AL-BAHA UNIVERSITY
COLLEGE OF ENGINEERING

المملكة العربية السعودية
وزارة التعليم العالي
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Further tests on thin steel and composite fabricated stubs

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1. Introduction:

Structural Steel:

* High strength

* Light weight

* Ductile material

* Bolted or welded

* Excellent seismic behaviour

* Rapid erection

Reinforced Concrete:

* Compresive stength

* Heavy weight

* Monolithic

* Suffer at seismic

* Need formwork

* Long time erection

Concrete-filled steel:

* Higher strength

* Moderate weight

* Ductile

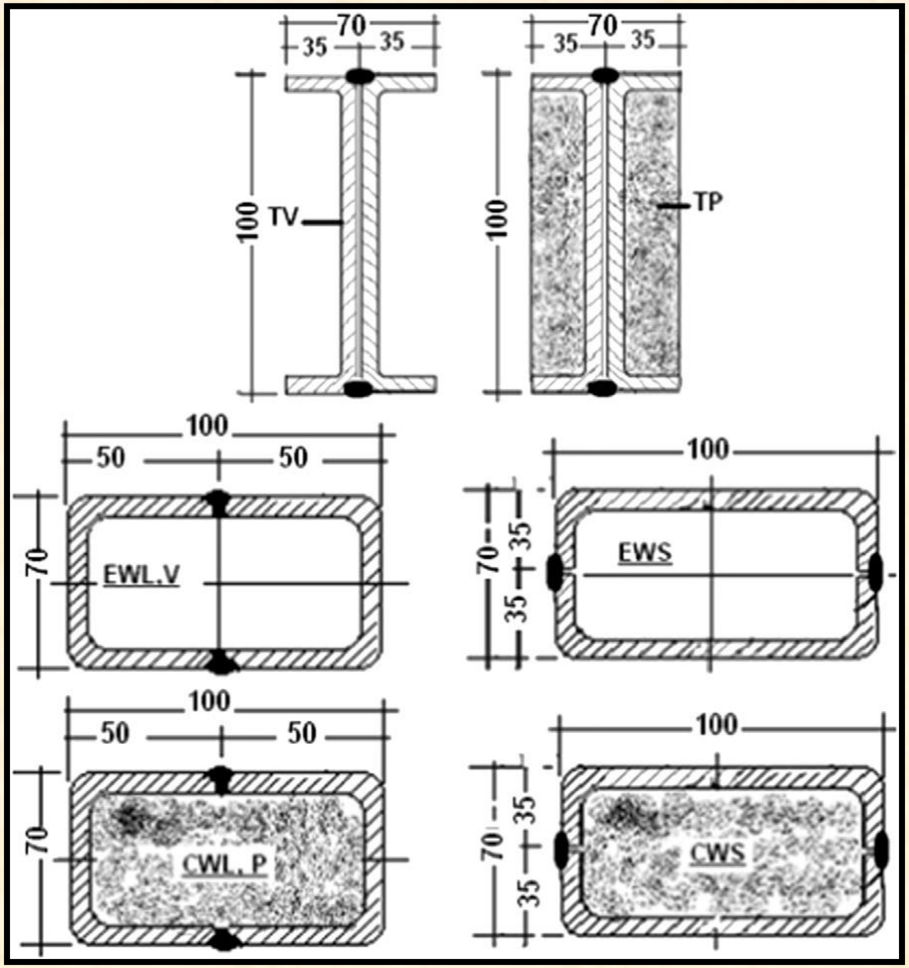
* Bolted or welded

* Excellent seismic

* Rapid erection

Concrete-filled thin steel → Local Buckling effect

2. Experimental program



Main studied parameters:

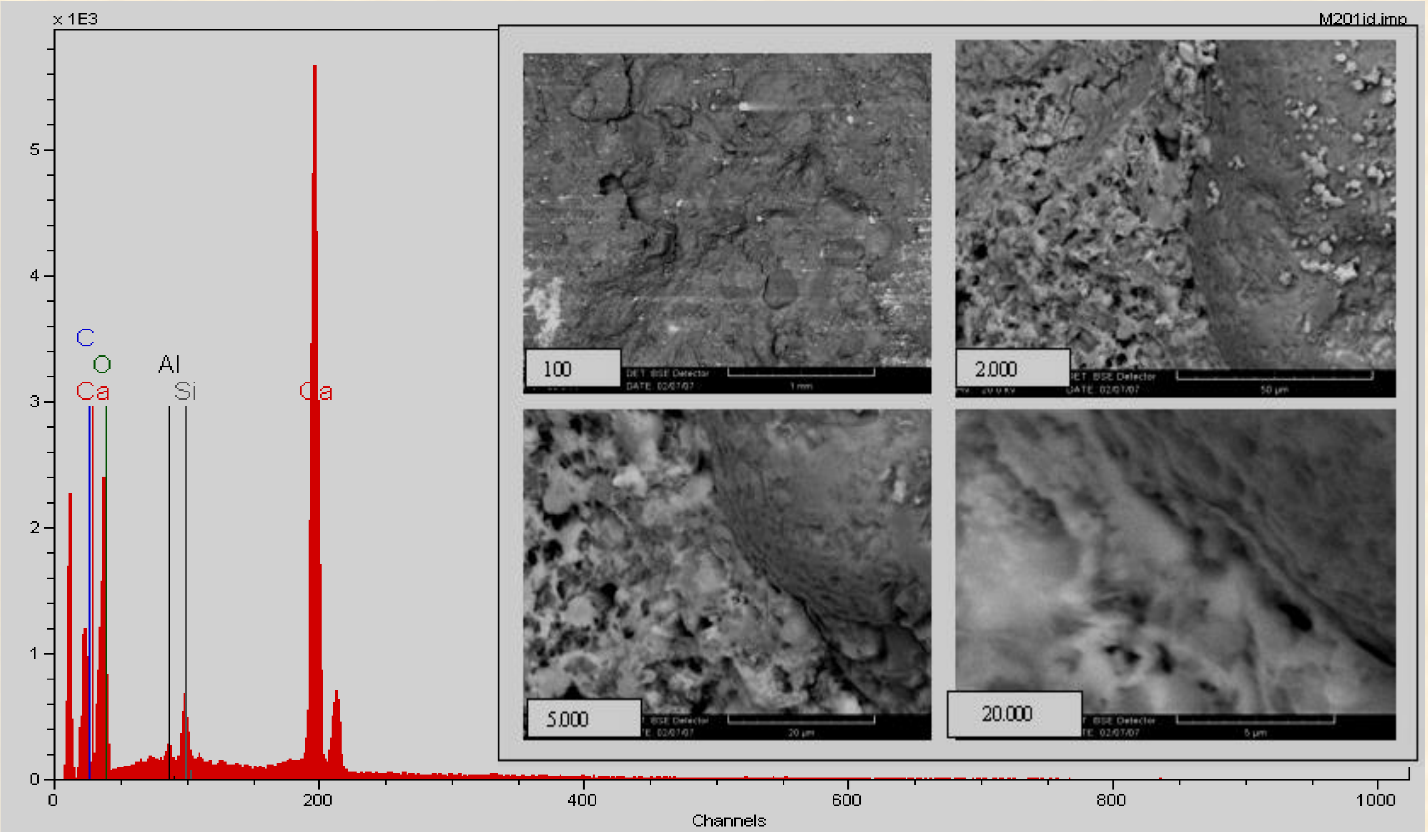
- The cross section shape
- The Stub height(50-500mm)
- The in filled concrete and its age
- The welding nature
- The welding location

3. Materials and fabrication

Steel: f_y=300. MPa, f_u=410. MPa, E_s=205GPa

Table 1
Slag concrete mix properties.

Cement content	350 kg/m^3
Water–cement ratio	.50
10 mm crushed slag stones	1200 kg/m^3
Sand 2/5	600 kg/m^3
Slump	70 mm
Compressive strength at 28 days	20 MPa
Compressive strength at 3 years	30 MPa
EC	21 GPa

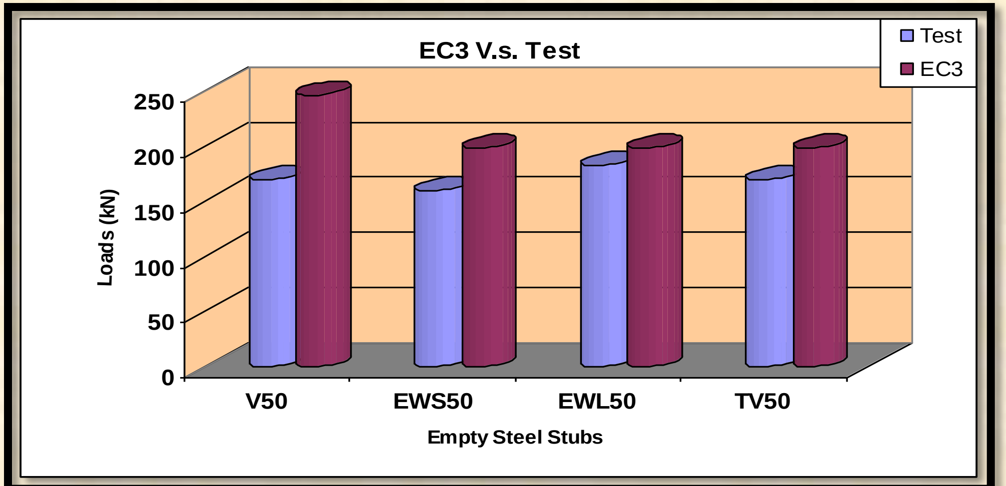


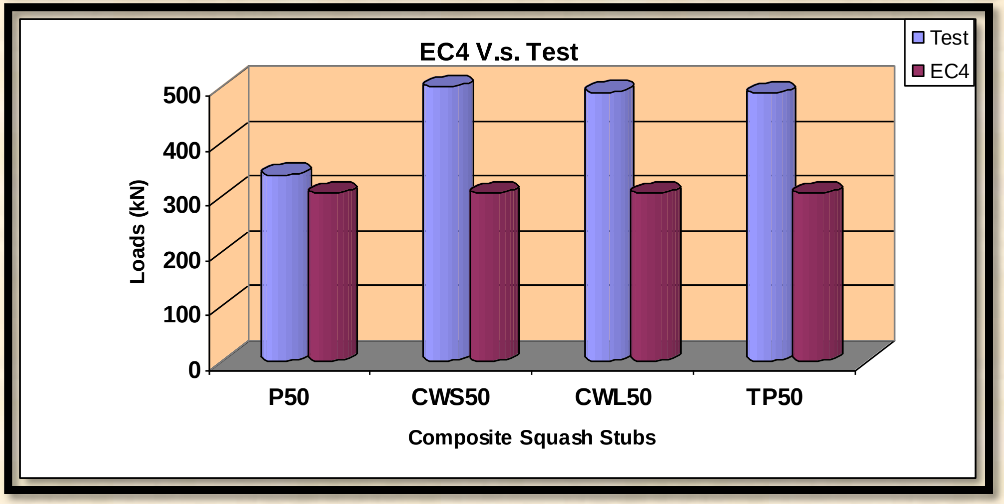
Slag concrete X-rays analysis and SEM Views

4. Experimental non-buckling squash loads

Table 2
Experimental non-buckling squash loads for all series.

Stub ref. (1)	H (mm) (2)	B (mm) (3)	T (mm) (4)	Test (kN) (5)	Filled/ empty (6)	EC3 (kN) (7)	EC4 (kN) (8)	EC/ Test (9)
V50	97	72	2.4	170.	2.00	247	-	1.45
P50	99	69	2.5	340.		-	306	0.90
EWS50	97	71	2.3	160.	3.12	199	-	1.24
CWS50	98	74	2	500.		-	306	0.61
EWL50	96	74	2	183.	2.67	199	-	1.08
CWL50	94	72	2	490.		-	306	0.62
TV50	96	74	2	170.	2.87	199	-	1.17
TP50	98	75	2	488.		-	306	0.62





5. Finite elements modeling

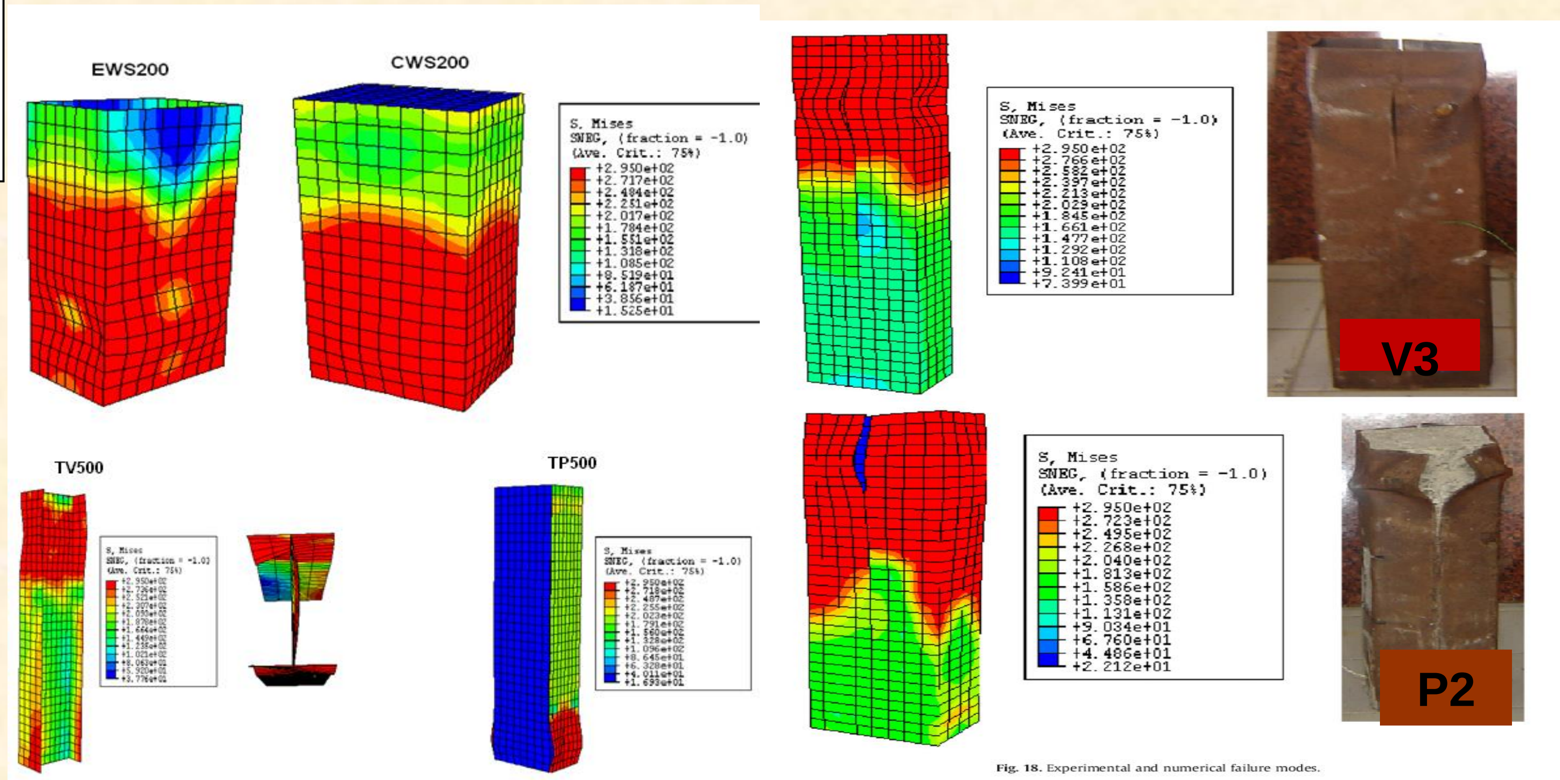
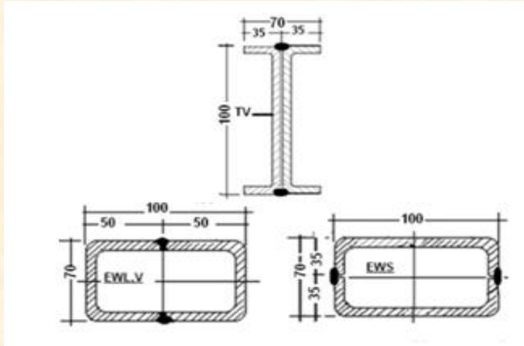


Fig. 18. Experimental and numerical failure modes.

Steel: Thin shell element
Concrete: Thick shell element
Welding: welding element

6. Test results



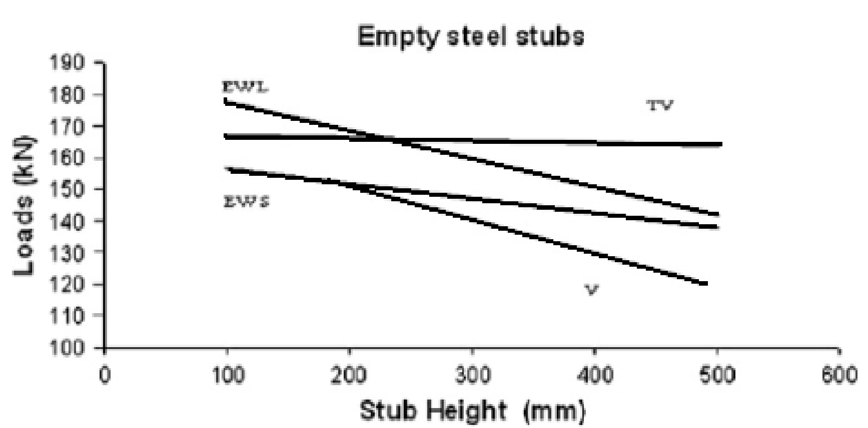
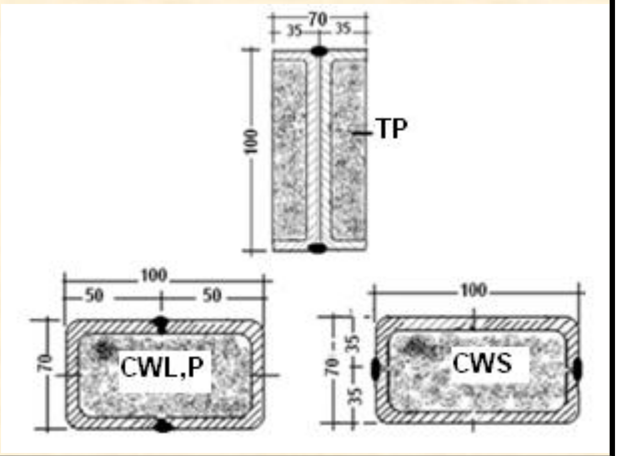


Fig. 7. Experimental ultimate loads for empty steel stubs.

Table 3
Results for empty steel stubs.

Stub ref. (1)	H (mm) (2)	B (mm) (3)	T (mm) (4)	L (mm) (5)	Test load (kN) (6)	FEM load (kN) (7)	EC3 (kN) (8)	FEM/ Test (9)	EC3/ Test (10)
V1	97	72	2.4	196	150	147.5	247	0.984	1.64
V2	99	69	2.5	298	146	144.7	247	0.991	1.69
V3	97	71	2.3	390	130	128.9	247	0.992	1.90
V4	100	70	2.4	490	120	119.2	247	0.994	2.05
EWL100	98	74	2	100	180	178.4	199	0.99	1.10
EWL150	98	74	2	149	174	173.8	199	0.99	1.14
EWL200	96	74	2	198	169	165	199	0.98	1.17
EWL300	94	72	2	295	154	153.7	199	0.99	1.29
EWL400	96	74	2	395	150	148.	199	0.99	1.32
EWL500	98	75	2	490	145	142.1	199	0.98	1.37
EWS100	102	68	2	100	159	161	199	1.01	1.25
EWS150	102	68	2	150	156	154	199	0.98	1.27
EWS200	102	68	2	200	148	145	199	0.98	1.34
EWS300	103	68	2	295	146	144	199	0.97	1.36
EWS400	104	68	2	395	141	140	199	0.99	1.41
EWS500	104	68	2	490	140	138	199	0.99	1.42
TV100	99.9	69	1.95	100	168	165	199	0.98	1.18
TV150	100	68	1.95	150	167	163	199	0.97	1.19
TV200	101	69	1.91	200	166	160	199	0.96	1.19
TV300	99	69	2	300	165	158	196	0.95	1.18
TV400	100	68	2	400	165	155	191	0.94	1.15
TV500	100	68	2	500	164	153	186	0.93	1.13

6. Test results



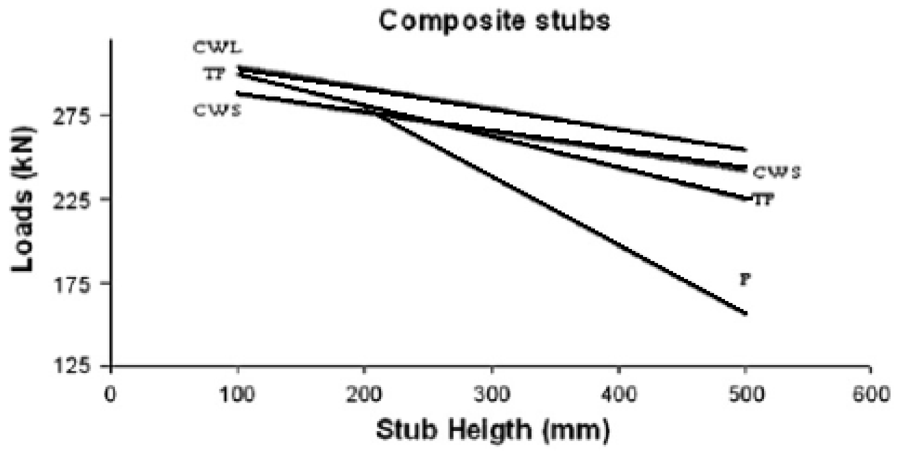


Fig. 8. Experimental ultimate loads for composite stubs.

Table 4

Results for composite concrete-filled steel stubs.

Stub ref. (1)	H (mm) (2)	B (mm) (3)	t (mm) (4)	L (mm) (5)	[a]Test load (kN) (6)	Filled/empty (7)	FEM (kN) (8)	EC4 (kN) (9)	FEM/Test (10)	EC4/Test (11)
P1	102	70	2.1	200	280/347	1.86/2.31	290/323	306/404	1.03/0.93	1.09/1.16
P2	102	70	2.0	300	230/344	1.57/2.35	240/329	306/404	1.04/0.96	1.33/1.17
P3	99	73	2.0	400	210/339	1.61/2.60	220/303	306/404	1.04/0.89	1.45/1.19
P4	100	72	2.1	500	150/264	1.25/2.20	145/249	303/400	0.96/0.95	2.02/1.51
CWL100	98	74	2	100	310	1.72	315	306	1.01	0.98
CWL150	98	73	2	150	300	1.72	302	306	1.02	1.02
CWL200	95	74	2	200	290	1.71	288	306	0.99	1.05
CWL300	95	74	2	300	270	1.75	271	306	1.00	1.13
CWL400	95	75	2	400	265	1.76	264.7	306	0.99	1.15
CWL500	97	75	2	500	260	1.79	257.6	303	0.99	1.16
CWS100	102	68	2	150	290	1.82	285	306	0.98	1.05
CWS150	104	68	2	150	285	1.82	290	306	1.01	1.07
CWS200	102	68	2	200	270	1.82	280	306	1.03	1.13
CWS300	103	68	2	300	265	1.81	260	306	0.98	1.15
CWS400	102	67	2	400	250	1.77	255	306	1.02	1.22
CWS500	102	67	2	500	245	1.75	240	303	0.98	1.23
TP100	100	69	2	100	298	1.77	300	306	1.00	1.02
TP150	101	68	1.97	150	289	1.73	295	306	1.02	1.05
TP200	101	69	1.91	200	280	1.68	278	306	0.99	1.09
TP300	100	68	2	300	264	1.60	260	306	0.98	1.15
TP400	100	68	2	400	249	1.50	253	300	1.01	1.20
TP500	101	68	2	500	220	1.34	215	294	0.97	1.33

[a] 28 days loads/3 years loads for P1 to P4.

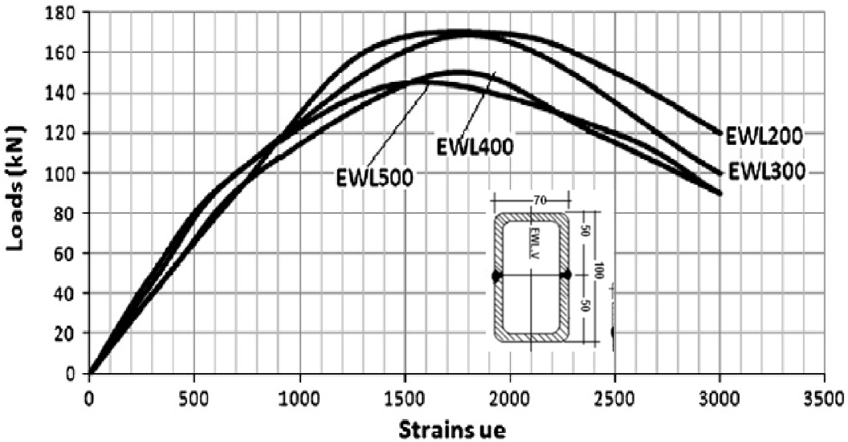


Fig. 10. Experimental load–strain variation for empty steel stubs, EWL series.

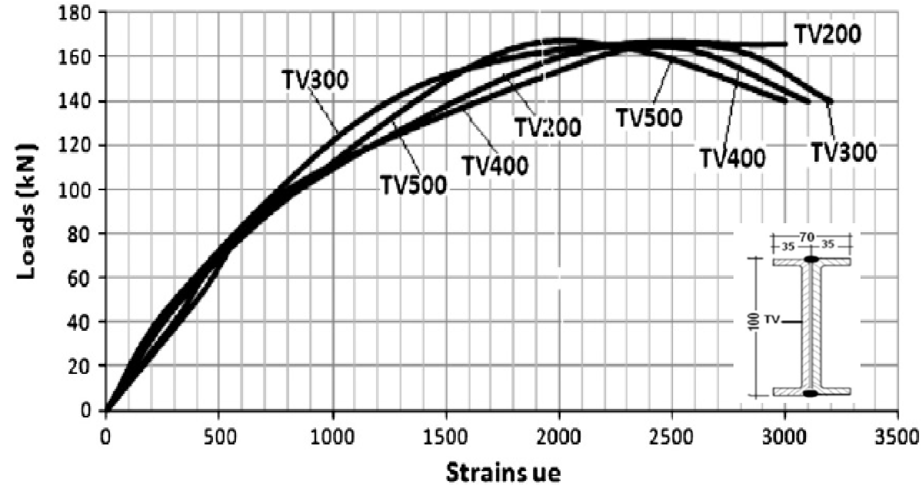


Fig. 12. Experimental load–strain variation for empty steel stubs, TV series.

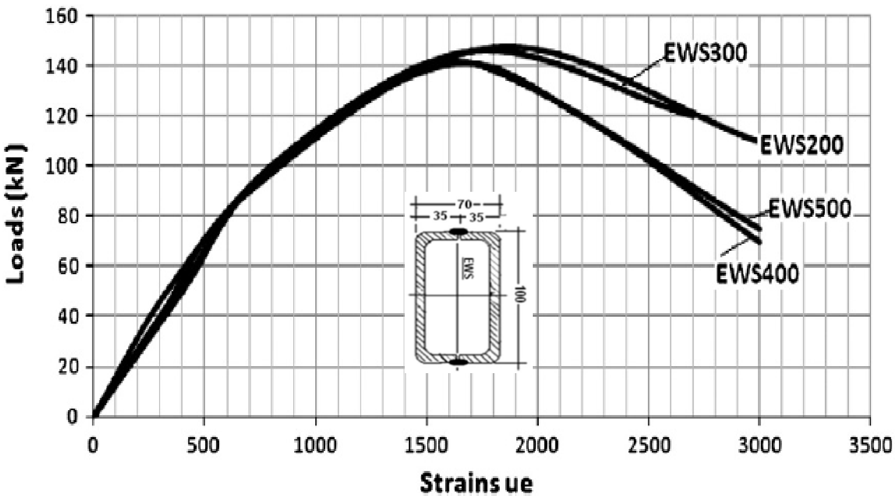


Fig. 11. Experimental load–strain variation for empty steel stubs, EWS series.

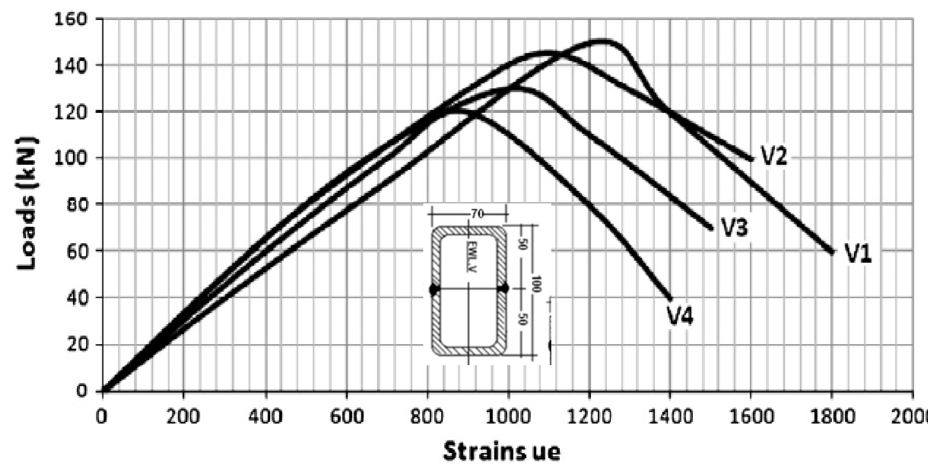


Fig. 9. Experimental load–strain variation for empty steel stubs, V series.

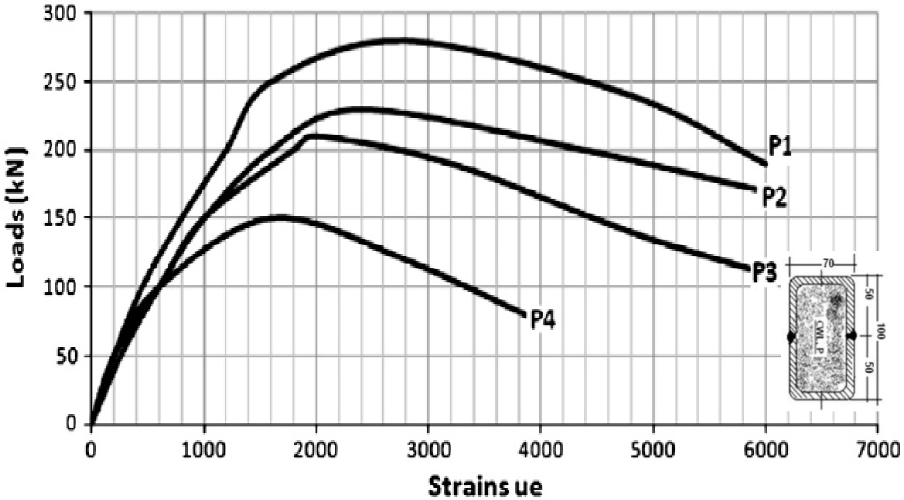


Fig. 13. Experimental load–strain variation for composite stubs, P series.

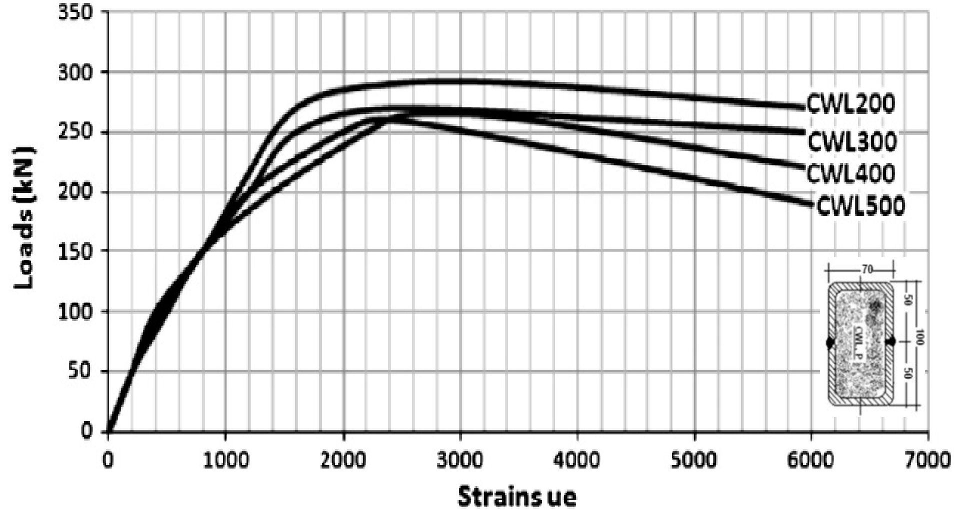


Fig. 14. Experimental load–strain variation for composite stubs, CWL series.

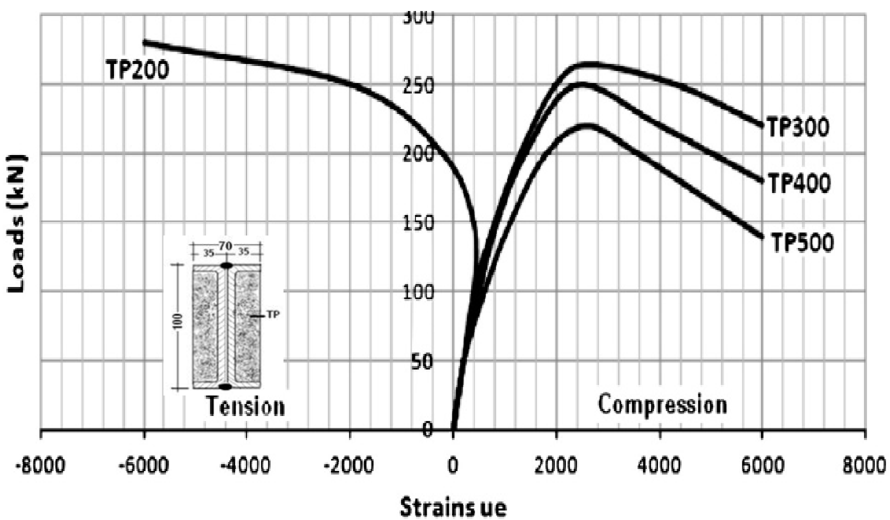


Fig. 16. Experimental load–strain variation for composite stubs, TP series.

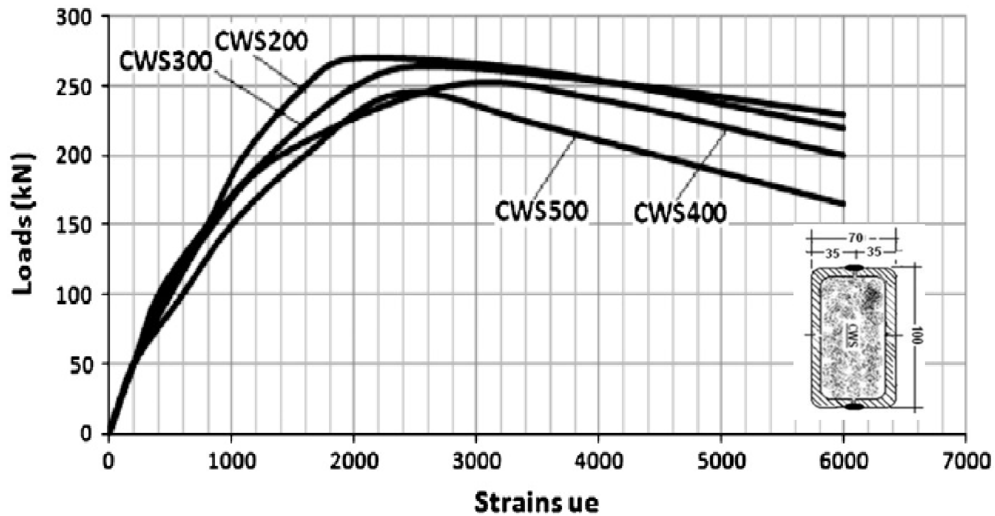
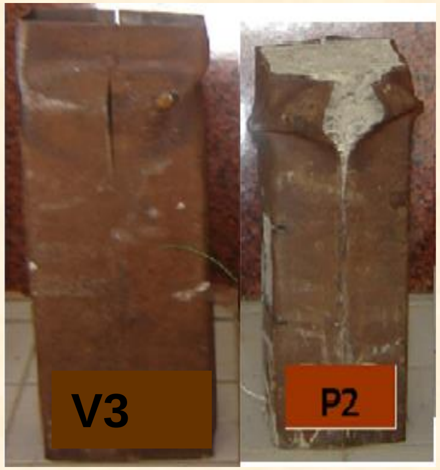


Fig. 15. Experimental load–strain variation for composite stubs, CWS series.



V & P samples

TV series

TP series after test

TV series after test

EW & CW samples after test

Conclusion:

Empty thin steel stubs strength was affected by:

Shape, length, welding nature and its location.

More strength is reached for composite stubs. Discontnous welding had a decreasing effect on squash loads.

The **age of concrete** increased the composite strength.

The F.E. models gave acceptable results.

The failure mode for thin steel stubs is by **local buckling** and by **steel yielding and concrete crushing** for composite stubs

Thank you for your attention

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