STUDY ON STRUCTURAL BEHAVIOUR OF TRANSMISSION LINE TOWER USING GFRP MATERIAL

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Abstract - *This thesis deals with the excremental investigation on the properties of GFRP (Glass Fiber Reinforced Polymer) In this Thesis we use the GFRP to find out the behavior of the final product made by this material which is line transmission tower. Due to the rapid population growth and rapid urbanization the natural resources are depleting day by day. So the natural aggregates are very hard to obtain. So many people are opting to use the GFRP (Glass Fiber Reinforced Polymer) instead of the conventional iron or steel channels. The cost of conventional iron or steel channels as compared to GFRP is also very high due to the high demand of it in construction works.*

GFRP will reduce the quarrying and mining of iron and steel ores thereby reducing the use of natural resources excessively. The land surface can be prevented from any unwanted excavation and hence ecological disturbances will be reduced to conserve the conventional natural iron ore for other important construction works.

The compression and the tensile tests are carried out in the thesis to find out the behavior of the different types of the joints and channel sections with different types of connections. And the result is carried out and accordingly the conclusion is given.

***Key Words*: GFRP (Glass Fiber Reinforced Polymer), Transmission tower, Urbanization, Construction.**

1. INTRODUCTION.

A "composite material" is made of two or more constituent materials with different physical and chemical properties. The composite components remain separate and distinct on a microscopic level within the finished structure, which is designed to have specific properties.

FRP (Fiber Reinforced Polymer) material was first used at the start of the 20th century as a niche application for military use. Now, FRP composite materials are widely used in various industries such as aerospace, automotive, construction, sport and recreation, marine and energy.

Because using FRP bars to replace steel bars can significantly improve the durability and reduce the life-cycle costs of the concrete structures, concrete structures reinforced with FRP bars, pre stressed FRP bars and FRP anchor bolts are being more and more used in bridge, offshore structures, nuclear reactor engineering, airport pavement, underground constructions and coal mine tunnel structures with the promulgation and implementation of the design specifications.

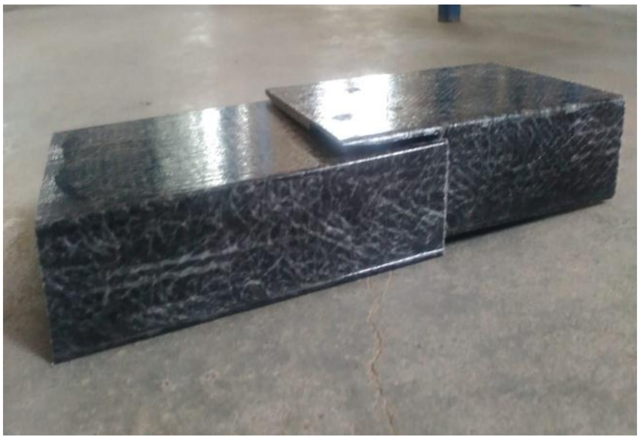


Fig-1 Glass Fiber Reinforced Polymer

1.1 VARIOUS TYPES OF FIBERS

1 Natural or Organic Fiber:

- Jute fiber
- Coir fiber
- Bamboo fiber
- Sisal Fiber

2 Inorganic Fibers:

- Glass fiber
- Carbon fiber
- Aramid fiber

1.1.1 Glass Fiber

Glass fibers are glass drawn into finer filaments of 7 to 24 microns. Because of the all-round properties and low cost, almost 95 % of composites used for the general and industrial applications are with glass fibers as reinforcements.

Fig-2 Glass Fiber

2 SCOPE

Pultruded sections of Fiber Reinforced composite material are one of the emerging construction materials. Light weight, High strength, good corrosion and fire resistance including

Tailor able properties are the attractive features for considering such materials as favourable one by the Engineers, Constructors, Academicians and other personnel involved.

While there materials are quite frequently used materials in western countries including china in various fields, the momentum in our nation has not yet picked up due to lack of reasonable research in the field. While FRP materials are prevalently used in Aeronautical/Space industries, utilization in construction sector is very scarce and limited.

Transmission tower are vital structures both in power sector as well as in communication sector constructed so far only using conventional metallic angle/channel sections such towers while exposed to adverse environmental conditions undergo gradual/sudden degradation/deteriorated due to corrosion or other defects.

3 MATERIAL PROPERTIES

Composite material made of a polymer reinforced with Fibers. Consist of thermosetting resins and glass Fiber. The manufacturing process involves the addition polymerization and step growth polymerization .the plastic which is under polymerization is mixed with glass Fiber, enhance the strength and elasticity of the plastic .this results in the formation of glass Fiber reinforced plastics GFRP).

4 CONNECTION DETAILS

4.1 TYPES OF JOINTS

- Butt joint
- Lap joint

4.2 TYPES OF CONNECTIONS

- Bolted connection
- Adhesive connection
- Combined or Hybrid connection

4.3 JOINT CONNECTIONS WITH BOLTS

- BUTT JOINT-BOLTED CONNECTION
- BUTT JOINT – ADHESIVE CONNECTION
- LAP JOINT-BOLTED CONNECTION
- LAP JOINT- ADHESIVE CONNECTION

4.1.1 BUTT JOINT

A butt joint is a technique in which two pieces of materials are joined by simply placing their ends together without any special shaping. The name 'butt joint' comes from the way of material is joined together. The butt joint is the simplest joint to make since it merely involves cutting the wood to the appropriate length and butting them together.

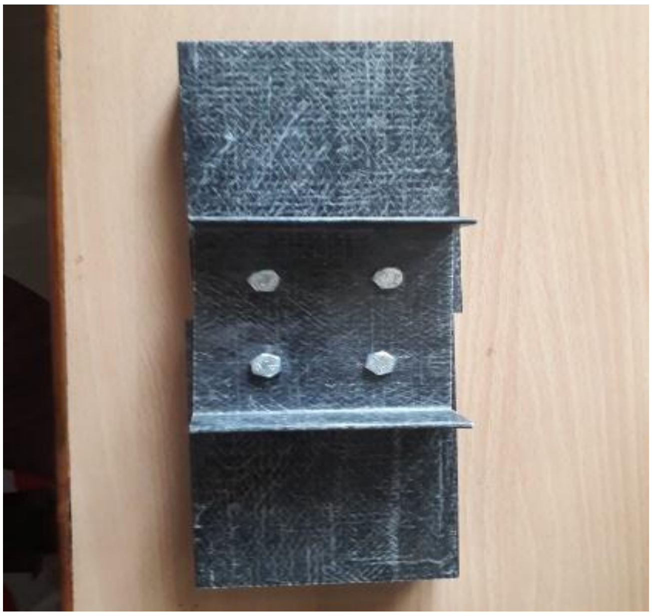


Fig-3 Butt Joint

4.1.2 LAP JOINT

A lap joint or overlap joint is a joint in which the members overlap. Lap joints can be used to join wood, plastics and metals.

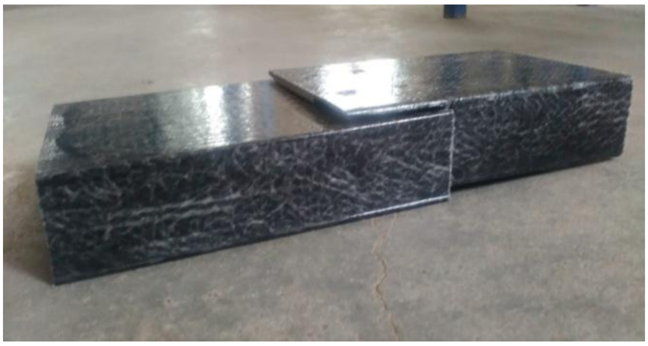


Fig-4 lap joint

4.2.1 BOLTED CONNECTION

To achieve an efficient bolted joint design, the structural two limitations are mainly considered. First, composites are too brittle to be analyzed using the conventional ,fully plastic method of designing metallic bolted joints because composite fibers fail in a brittle mode at a typical strain level of 2%, whereas ductile metals13% before failure, enabling drastic load redistribution between the fasteners. Second, the use of linear elastic analysis is equally inappropriate due to the great strength increase resulting from begin micro failures in the immediate vicinity of small bolt holes.

4.2.2 ADHESIVES

Adhesive is a general term used for substances (e.g., cement, glue and paste) capable of holding materials together by surface attachment. Adhesion is associated with intermolecular forces acting across an interface and involves a consideration of surface energies and interfacial tensions. The materials being joined are referred to as the "adherents" or "substrates".

4.2.3 COMBINED CONNECTION

In combination joints, both adhesives and mechanical fasteners are used. This method of joining composites can provide the joint with greater capacity and reliability. In combined joints, the inherent strengths of the component elements are enhanced to produce a joint that displays significantly improved performance.

4.3.1 BUTT JOINT-BOLTED CONNECTION

In butt joint, there is a gusset plate size 5cm *10cm used to connect the respective two GFRP materials .The minimum available bolts size 6mm is used in this connection .Three types of connections are made such as 4 bolted , 6 bolted and 8 bolted with the same sizes of gusset plates.

Butt Joint-Bolted Connection

4.3.2 BUTT JOINT – ADHESIVE CONNECTION

In these connections, also the gusset plates size 5cm*10cm are used .but the small change of connecting agent as adhesive (resins) is used .first the two specimens are connected and further the gusset plates are providing for the extra support.

Butt Joint – Adhesive Connection

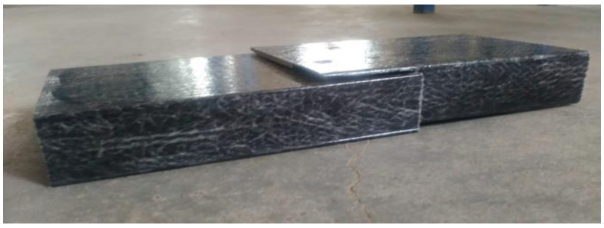
4.3.3 LAP JOINT-BOLTED CONNECTION

In lap joint, there is a concept of overlapping in the specified size of 5cm of two materials for their respective number of bolts. 4bolted and 6bolted connections are made without any risk. But in 8bolted lap there is a risk in spacing between bolts.

Lap Joint-Bolted Connection

4.3.4 LAP JOINT- ADHESIVE CONNECTION

In lap joint, there is a second choice of using adhesives as a connecting agent. The overlapping space as like that of gusset plate size 5cm .it is a quicker reaction of connecting two materials.



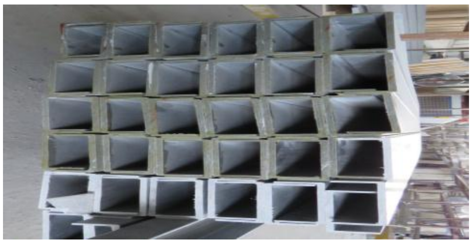
Lap Joint-Adhesive Connection

4. LABORATORY PROCESS

Marking: The required dimensions of hole drillings are initially marked and further specimens are drilled for its desired shape.

Marking

Cutting: Initially the specimens are shapely cut in the size of 15cm as length for each type of connections. Dimension of the width of the specimen taken is 50mm.



Cutting

Drilling: The minimum size of drilling is made that is 6mm bolted holes.

Drilling

5 EXPERIMENTAL STUDIES

The Various Connections of Channel Sections are done by proper drilling and markings. The connections are tightened by fasteners. The various connections and its descriptions are mentioned below.

TYPES OF JOINTS	DESCRIPTION	BOLTED			ADHESIVE JOINT	HYBRID		
		4	6	8		4	6	8
Butt	Length	30	30	30	30	30	30	30
	Width	10	10	10	10	10	10	10
	Thickness	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	No. of Specimen	2	2	2	2	2	2	2
	Max. Force	96.9	44.2	38.4	42.06	300	278	38.5
Lap	Length	25	25	25	25	25	25	25
	Width	10	10	10	10	10	10	10
	Thickness	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	No. of Specimen	2	2	2	2	2	2	2
	Max. Force	26.9	102	78.7	30.53	148	99	75.3

Table-1 Description of Channel Section and its connection

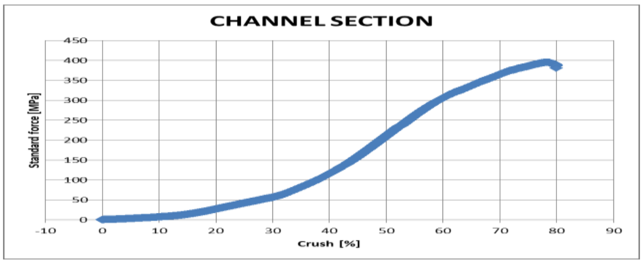
6 RESULTS AND DISCUSSION

6.1 TESTING OF GRPF CHANNEL SECTION

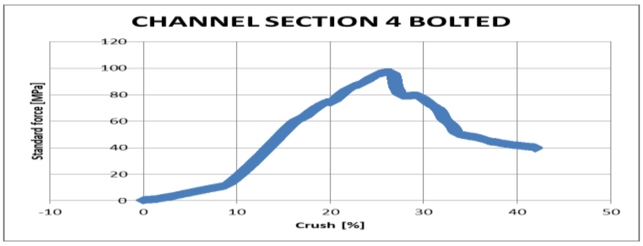
The following are the various properties test of the GFRP channel section and its connection tests.

6.1.1 COMPRESSION TEST

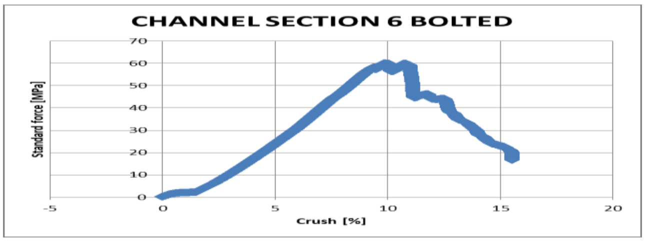
Compression test are performed according to ASTM D-695 to evaluate the behavior of the material when it is subjected to compressive load. Samples are placed between two parallel platens in a universal testing machine and then slowly compressed at low and uniform rate. The maximum load is recorded as well as stress / strain data. The material compressive modulus can be obtained using this test.



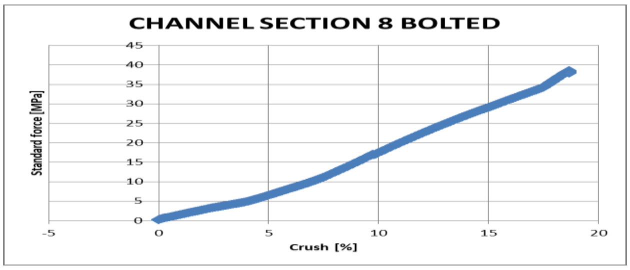
Compression test of Channel Section



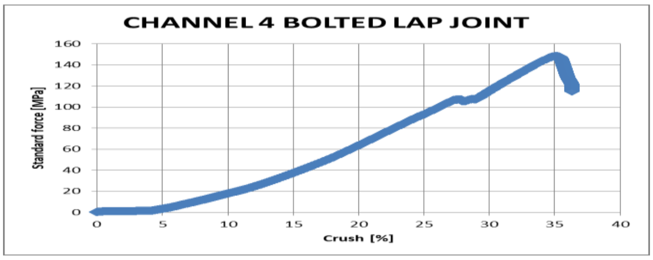
Compression test of 4 Bolted Channel Butt Joint



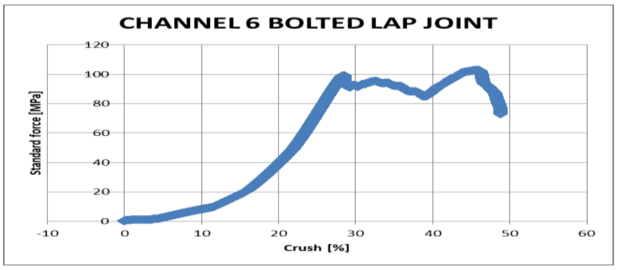
Compression test of 6 Bolted Channel Butt Joint



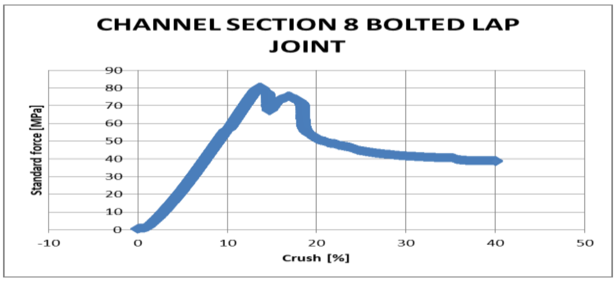
Compression test of 8 Bolted Channel Butt Joint



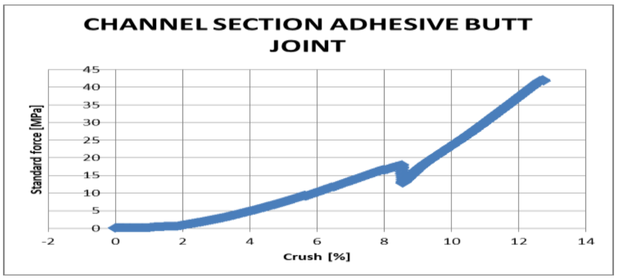
Compression test of 4 Bolted Channel Lap Joint



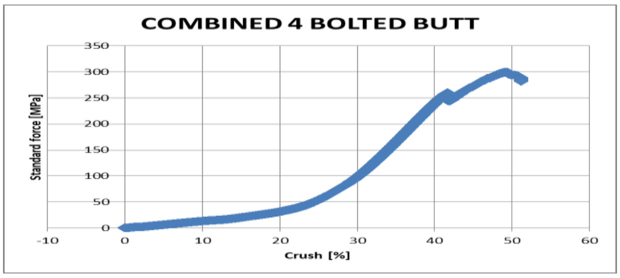
Compression test of 6 Bolted Channel Lap Joint



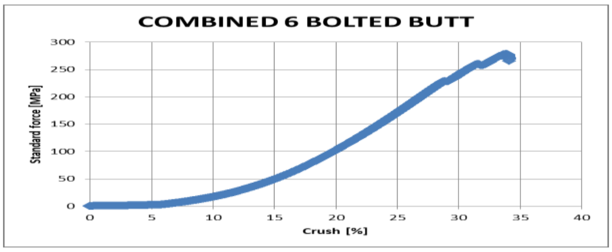
Compression test of 8 Bolted Channel Lap Joint



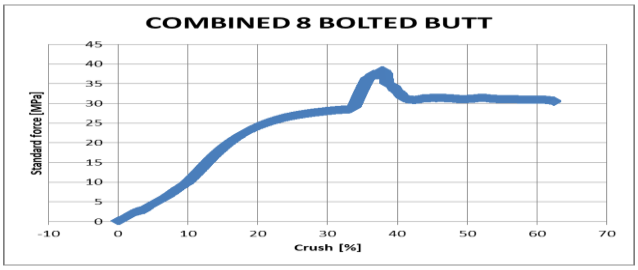
Compression test of Channel Adhesive Butt Joint



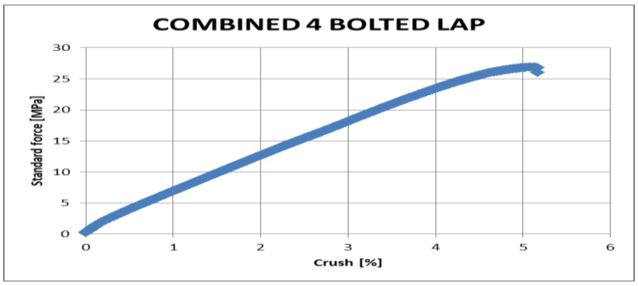
Compression test of Channel Combined 4 bolted Butt Joint



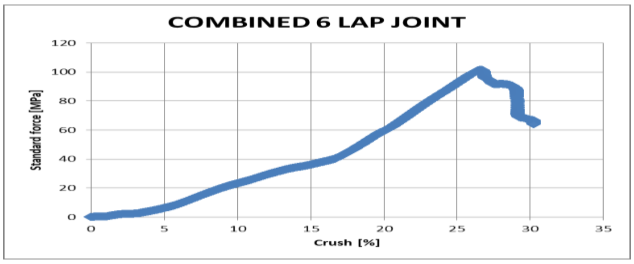
Compression test of Channel Combined 6 bolted Butt Joint



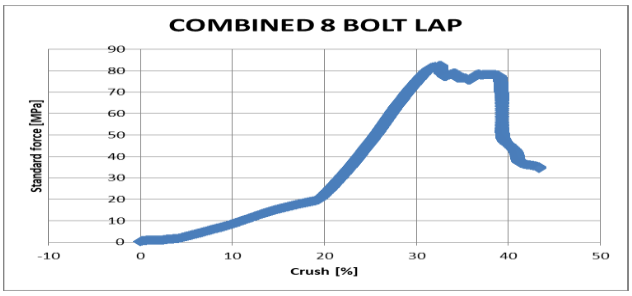
Compression test of Channel Combined 8 bolted Butt Joint



Compression test of Channel Combined 4 bolted Lap Joint



Compression test of Channel Combined 6 bolted Lap Joint



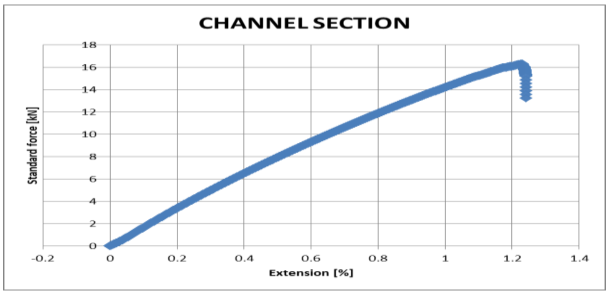
Compression test of Channel Combined 8 bolted Lap Joint

6.1.2 TENSILE TEST

Tension tests are performed according to ASTM D-3039 using coupons placed in a universal testing machine. A tensile load is slowly and uniformly applied to the sample until it fails. An extensometer may be located on the area to measure the extension as the load is applied. The load magnitude and extension are recorded. Values for tensile strength and tensile modulus can be obtained with the test can be performed on new and aged samples to determine any changes in property

Specimen ID	E MPa	P N	S MPa	Ɛ at failure %	h mm	b mm	A mm²
Channel	22132.19	16287.41	217.1655	1.242937801	6	12.5	75

Table-2 Tensile test of Channel Section



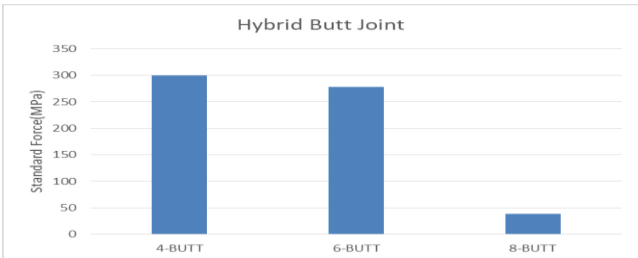
Tensile test of Channel Section

6.2 DISCUSSION

According to our experiments, the various connections of channel sections based on the bolts and adhesive are taken into account by the crush (%) and its Standard Force (MPa). The above mentioned graphs give the values of the various connections. This shows that the Hybrid connections experience more Forces.

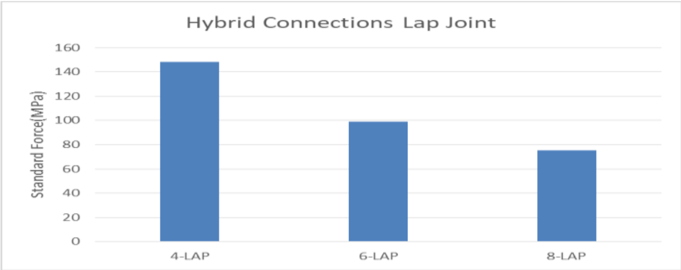
6.2.1 THE HYBRID CONNECTION

The Hybrid butt joints of various bolted connection are graphed by standard forces on the Vertical axis. This shows that the forces exerted by 4-bolted Hybrid butt joints are high as compared to the other connections.



Comparison of Hybrid Butt 4 6 8 bolted Joint

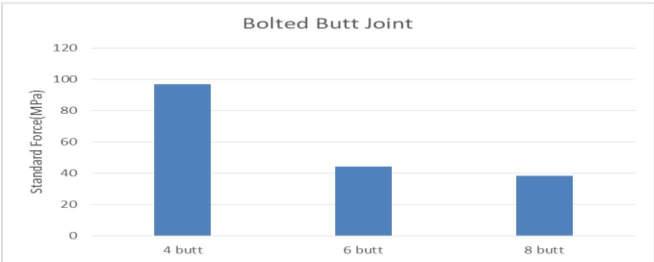
The Hybrid Lap joints of various bolted connection are graphed by standard forces on the Vertical axis. This shows that the forces exerted by 4-bolted Hybrid Lap joints are high as compared to the other connections.



Comparison of Hybrid Lap 4 6 8 bolted Joint

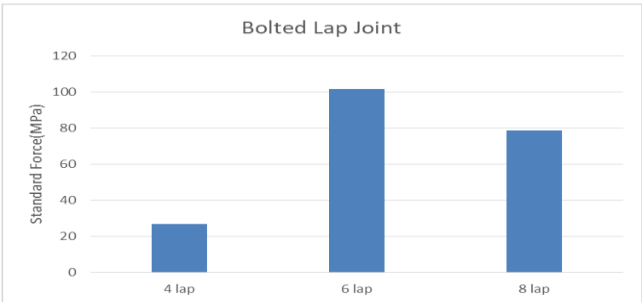
6.2.2 BOLTED CONNECTION

The bolted connections of butt joints are graphed by standard forces on the Vertical axis. This shows that the forces exerted by 4-bolted butt joints are high as compared to the other connections.



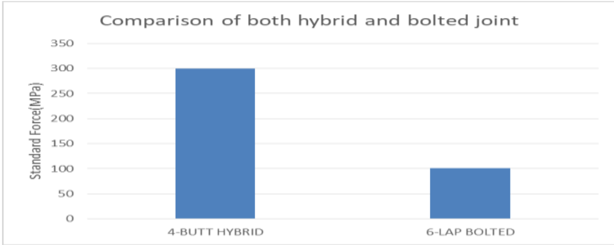
Comparison of Butt Joints of 4 6 8 bolted Joint

The bolted connections of lap joints are graphed by standard forces on the Vertical axis. This shows that the forces exerted by 6-bolted lap joints are high as compared to the other connections.



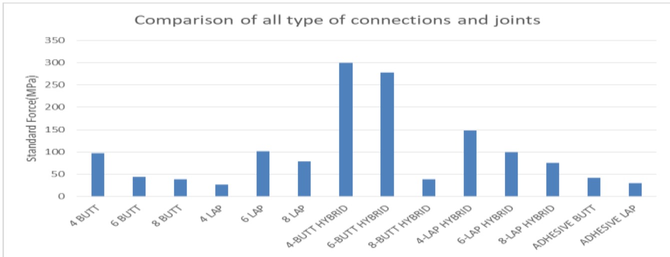
Comparison of lap Joints of 4 6 8 bolted Joint

From the four graphs the 4-bolted Combined Butt Joint and the 6 bolted Lap joints are compared and Plotted in the Same Graph. This clearly shows that the 4-bolted combined Butt joints have high values.



Comparison of 4-Bolted Hybrid Butt and 6-Bolted Lap Joint

By analyzing all the sections the maximum force that experienced by all the various connections are charted below.



Comparison of all type of Connection and Joints

SPECIMEN ID	σ_{low}	σ_{high}	$L_{0\,CH}$	E_c	E_{Sec}	$\sigma_{0.1}$	σ_2	σ_M	ε_M	ε_{cM}	$\varepsilon_{M\,(Corr.)}$	L_0
CHANNEL SECTION 4 BOULT BUTT JOINT	0.28074	0.535207	7.29	0.119905	0.084555	0.799956	1.881745	96.86725	26.30161	26.30161	26.50576	7.29
CHANNEL SECTION 6 BOULT BUTT JOINT	0.364705	1.012843	7.29	0.318393	0.198758	1.75956	4.73905	60.03841	9.87823	9.87823	9.941796	7.29
CHANNEL SECTION 8 BOULT BUTT JOINT	0.269707	0.606369	7.29	0.166555	0.134136	0.856224	2.700384	38.52007	18.70349	18.70349	18.82744	7.29
CHANNEL SECTION 4 BOULT BUTT JOINT HYBRID	0.092601	0.110733	7.29	0.008453		0.108422	1.677117	299.4468	49.36601	49.36601	50.42275	7.29
CHANNEL SECTION 6 BOULT BUTT JOINT HYBRID	0.224945	0.501256	7.29	0.138025	0.113844	0.949783	1.23749	278.0634	33.87774	33.87774	33.9951	7.29
CHANNEL SECTION 8 BOULT BUTT JOINT HYBRID	0.175249	0.253061	7.29	0.028327	0.037137	0.171142	1.969178	38.4017	37.90654	37.90654	38.43725	7.29
CHANNEL SECTION 4 BOULT LAP JOINT	0.225246	0.478312	7.29	0.125171	0.091204	0.881688	0.911422	148.1337	35.13975	35.13975	35.2779	7.29
CHANNEL SECTION 6 BOULT LAP JOINT	0.14107	0.181832	7.29	0.019452	0.019002	0.226186	1.920988	101.4284	26.63819	26.63819	27.33408	7.29
CHANNEL SECTION 8 BOULT LAP JOINT	0.260016	0.581672	7.29	0.162404	0.077858	0.664867	0.854808	82.40362	32.64496	32.64496	32.75832	7.29
CHANNEL SECTION 4 BOULT LAP JOINT HYBRID	0.703761	2.390536	7.29	0.85449	0.667916	4.486914	12.65224	26.85829	5.072095	5.072095	5.11181	7.29
CHANNEL SECTION 6 BOULT LAP JOINT HYBRID	0.231816	0.544378	7.29	0.153236	0.083654	0.767816	0.916388	102.7922	45.72091	45.72091	45.82666	7.29
CHANNEL SECTION 8 BOULT LAP JOINT HYBRID	0.519288	0.66731	7.29	0.074937	0.071234	0.733326	5.420013	80.44443	13.72025	13.72025	14.37529	7.29
CHANNEL SECTION ADHESIVE BUTT JOINT	0.107616	0.111733	7.29	0.001857		0.109134	0.876051	42.06946	12.74466	12.74466	18.55142	7.29
CHANNEL SECTION ADHESIVE LAP JOINT	0.198979	0.389146	7.29	0.095995	0.102303	1.321795	1.497406	35.99325	15.3606	15.3606	15.51487	7.29

Table-3 The compressive strain on hard plastics of various Connections and Joints

7 CONCLUSIONS

There is an increasing demand for alternatives to conventional construction materials in infrastructural applications in the present days. In this front, Fiber Reinforced Plastics (FRPs) has attracted a great deal of attention. But one of the obstacles towards widespread use of FRP materials in infrastructural applications is connection of FRP members. In order to use the FRP material in structural applications a better understanding of FRP connections and setting proper design methods is very important. This Paper deals with the different types of connection details of pultruded glass Fiber reinforced plastic (GFRP) angle sections such as mechanical, bonded and hybrid connections. Different aspects such load transfer mechanism and different failure modes have been presented. The literature review has been carried out. As per ASTM codes, the specimens were visually inspected to identified the surface defects in GFRP Specimens. The various connections made on the GFRP materials to identify the external loads like compression and lateral loads that were acts in the vertical columns on the transmission line towers were measured.

From this experiment we can concluded that the 4 bolted hybrid butt connections experiences the maximum forces, it can withstand more forces compared to the other connections and joints. If the transmission tower is constructed in Bolted connection, then it should be constructed with 6 bolted lap connection.

REFERENCES

[1] **Afiqah Nadhirah ,Salmia Beddu(2017)** Properties of Fiberglass Crossarm in Transmission Tower - A Review

[2] **P. Antonopoulo and Thanasis C. Triantafillou, M.ASCE** Experimental investigation of frp-strengthened Rc beam-column joints.

[3] **Girão-Coelho AM, Mottram JT(2015)** A review of the behaviour and analysis of bolted connections in pultruded Fiber reinforced polymers. Materials & Design 74, 86-107.

[4] **Hernandez.R – Corona and Ramirez – Vazuquez (2015)**"experimental investigation of rc beams strengthened with externally bonded frp composites"

[5] **ASTM D695**

[6] **IS 802(Part 1/Sec 1) : 1995**

BIOGRAPHIES

AAQIB FORDOUS is a Civil Engineer from the Anna University. His latest paper was "Design and analysis of 4 in 1 school complex" published in IRJET.