Use of Concrete Filled Unplasticised Polyvinyl Chloride Tubes (CFUT) as Column in Polyhouse

V. K.Verma[1], Tejkaran Singh Chawla[2], Manas Adhikari[2], Rajat Sella[2]
[1] Assistant Professor,
Civil Engineering Department

[2] B.Tech. Student of Civil Engineering
College of Technology Pantnagar, G.B. Pant University of Agricultural & Technology,
Pantnagar, Uttarakhand, India

***Abstract* - Nowadays polyhouses are in big use to safeguard the different varieties of plants all across the Indian mainland. The purpose of a polyhouse is to protect vegetable seedlings from wind, rain and to provide adequate light. The soil of terai region, particularly of Uttarakhand/ Uttar Pradesh, has xenobiotic chemicals and some alterations in the natural soil caused by industrial activity, agricultural chemicals which may harm to the structure. Therefore, a polyhouse of size 6'x6' is planned to be constructed in the vicinity of College of Technology, Pantnagar. This paper presents the analysis and design of Polyhouse, considering CFUT as a column which may provide the required protection to the structure against different chemicals present in soil. In this study, a conventional aluminum/steel section used as a column in polyhouse construction is tried to be replaced by a CFUT column. CFUT may also provide better strength and durability to the column. According to the statistics revealed by the World Bank in 2012-13 nearly 60.3 percent of the Indian land is involved in agricultural activities. It is expected that a number of polyhouses will significantly increase in the near future, thus leading to a great demand for them. Therefore, CFUT may provide an alternative for the structural member like column for polyhouse in aggressive environment.**

Keywords: Column, Polyhouse, CFUT, Strength, Durability

1. INTRODUCTION

India is a developing country and is undergoing rapid growth in its industrial sector which is leading to a considerable pollution in all forms. The country feeds more than a billion and it becomes essential to safeguard different varieties of crops and boost their production. One of the major implications of rapid industrialization is the outspread of pollution and with such an agricultural scenario, the soil is contaminated by xenobiotic chemicals and other alterations which may have a negative impact over the foundation of various major and minor structural entities. At its small scale, a case of a small town named Pantnagar in Uttarakhand state of the country, known for its Integrated Industrial Estate (IIE) i.e., SIDCUL and G.B. Pant University of Agricultural and Technology is taken into consideration. Pantnagar is situated in Northern India which has a characteristic cold weather during the winter season which may be adverse for the growth of vegetables like tomato, capsicum, cucurbits, French bean; amaranth etc. in fields (R.K.Yadav et al, 2014). These vegetable seedlings should be protected from such conditions of wind, rain (Kratky B.A. et al, 1986) and cold. With the evolving techniques and requirements, it was thought of an idea meeting both the issues i.e., foundation being corroded by the alterations and unfavorable conditions as mentioned before. In order to safeguard the vegetables and being a part of the agricultural university it is proposed to construct a polyhouse using concrete filled unplasticised tubular columns (CFUTs) with a case of plastic box at the base of the columns. Plastic being bio-non degradable in nature is unaffected by the organic matter or other corrosive aspects which may hamper the life of the structure and the box shape makes it easy to be employed. Gupta et al. (2013) performed experiments on concrete filled UPVC tubes using as column specimens. They studied different parameters like strength, confinement and ductility. They observed from the load-displacement variation that UPVC CFUT fails in ductile manner.

The objective of the research they concluded was that the confinement of concrete can be obtained using UPVC tubes. This study aims to analyze and design the truss over the columns in an area of 6' by 6'. The polyhouse is to be constructed using all the locally available materials, therefore apart from being sustainable, it is economical as well.

2. STRUCTURAL DESCRIPTION

The truss model can be elaborated as shown which is designed and analysed on STAAD Pro. software.

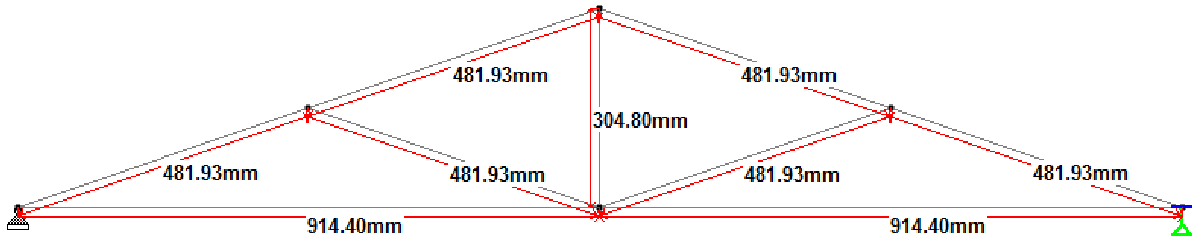

Figure 1- Model of Truss

2.1. Model

The front view of the truss model has been depicted as above in the Figure 1 whose dimensions are as mentioned below in the **Table 1**.

Table 1- Dimensions of truss members

Structural Member	Length (m)
Span	1.830
Spacing	1.830
Rise	0.300
Rafter	0.960
Column Height	1.830
Purlin Spacing	0.480 c/c

2.2 Loads

The loading conditions prevalent as per the IS 875 (PART 1, 2, 3): 1987 are as follows in Table 2. The load combinations as per IS 875: 1987 are 1.5(D.L. + L.L.) where D.L. is Dead Load and L.L. is Live Load.

Table 2- Magnitude of loads

Load Type	Value
Self weight (56.09 N/m^2)	0.05 kN
Unit weight of sheeting (70 N/m^2)	0.06 kN
Unit weight of purlin (180 N/m^2)	0.33 kN
Live Load*	0.51 kN
Crop Load	0.245 kN/m^2

*the wind loads at heights of 6' are neglected as per IS 875 (Part 3): 1987

The application of loads as per the combination load case has been depicted in Figure-2 below.

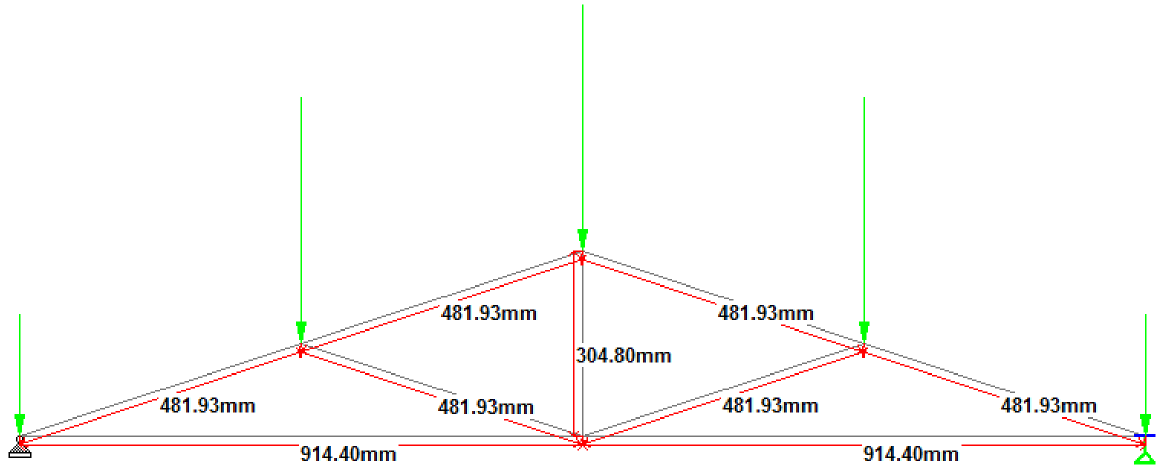

Figure 2- Application of Loads

Table 3- Sectional Properties

Designation (mm)	25.0x25.0x2.6
Depth or Width (mm)	25.0
Thickness (mm)	2.6
Weight (kg/m)	1.69
Area of section (cm^2)	2.16
Moment of Inertia (cm^4)	1.72
Radius of gyration (cm)	0.89
Elastic Modulus (cm^3)	1.38
Plastic Modulus (cm^3)	1.76

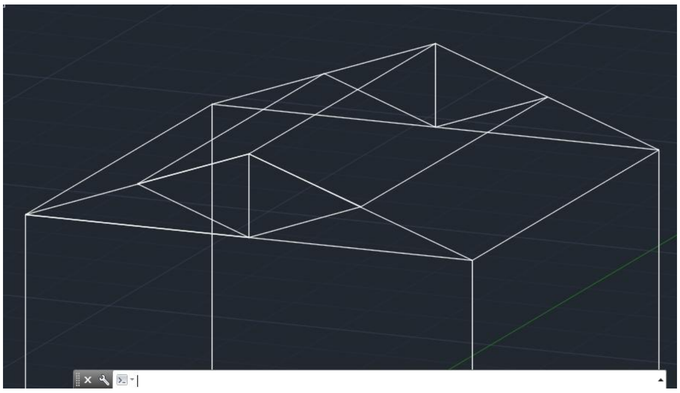

Figure 3- Three dimensional model of structure

2.3. Sectional Material

As per convention we opted for the least size and thickness of the square hollow section having dimensions as shown in Table 3. The section employed is TUB25252.6

2.4. Structural model

The model as shown consists of a projected area of 6'x6' over the site with the truss dimensions elaborated before. The CFUT columns are of height 6' with a proposed depth of 1' below the ground level.

3. ANALYSIS

The analysis of the structure is done on STAAD Pro. V8i as per IS 800: 2007 GENERAL CONSTRUCTION IN STEEL — CODE OF PRACTICE) and the report of the steel design has shown a maximum axial load of *5.01 kN*. The overall status of the entire structural member is **'PASS'** as per STAAD Pro. report, therefore it is permissible to employ the aforementioned section.

Table 4- Analysis results of the truss (Member end forces)

MEMBER	JOINT	AXIAL FORCE	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
1	1	-5.01	0.01	0.00	0.00	0.00	-0.02
	4	5.01	0.01	0.00	0.00	0.00	0.01
2	2	5.30	0.06	0.00	0.00	0.00	0.02
	5	-5.30	-0.04	0.00	0.00	0.00	0.06
3	3	3.65	0.04	0.00	0.00	0.00	0.02
	6	-3.66	-0.03	0.00	0.00	0.00	0.04
4	4	-5.01	0.01	0.00	0.00	0.00	-0.01
	2	5.01	0.01	0.00	0.00	0.00	0.02
5	4	-1.11	0.00	0.00	0.00	0.00	0.00
	3	1.12	0.00	0.00	0.00	0.00	0.00
6	5	3.66	-0.03	0.00	0.00	0.00	-0.04
	3	-3.65	0.04	0.00	0.00	0.00	-0.02
7	4	1.63	0.03	0.00	0.00	0.00	0.01
	5	-1.62	-0.02	0.00	0.00	0.00	0.03
8	6	5.30	-0.04	0.00	0.00	0.00	-0.06
	1	-5.30	0.06	0.00	0.00	0.00	-0.02
9	4	1.63	0.03	0.00	0.00	0.00	0.01
	6	-1.62	-0.02	0.00	0.00	0.00	0.03

4. DESIGN

The design of column section is done on the basis of load exerted by the truss. On the basis of IS 456: 2000, we design the column section for the model.

$$\mathbf{P_u = 0.4\mathit{f}_cA_c + 0.67\mathit{f}_yA_{sc}}$$

(From Clause 39.3 of IS 456:2000)

Where P_u is the design load on the member, f_c is the unconfined compressive strength of the concrete; A_c is the area of concrete, f_y characteristic strength of the reinforcement, and A_{sc} area of longitudinal reinforcement for columns.

Strength of unconfined concrete column = 0.4 x 20 x (π x150^2) / 4 + 0.67 x 250 x (25^2-19.8^2)

= 180.392 kN

$$\mathbf{f_c' = f_c + 4.1 f_l}$$

(Richart et al, 1928)

where f_c' is the confined compressive strength of concrete, f_c is the unconfined compressive strength and f_l is the confining pressure which is taken to be 0.6 MPa for class 3 UPVC pipes as per IS : 4985: 2000

f_c' = 20 + 4.1 x 0.6

= 22.46 N/mm^2

Strength of confined concrete column = 0.4 x (22.46 x π x 150^2) / 4 + 0.67 x 250 x (25^2-19.8^2)

= 197.81 kN

By using UPVC tube

% increase in strength =
[(197.81 – 180.392) / (180.392)] x 100
= 9.655 % i.e., approximately 10%

The maximum pressure or the bursting pressure of the sample of UPVC pipe employed for construction was found to be *1.96MP*, which is well above the specified value of *0.6MPa*. Hence, the actual value of the confining pressure is well above the desired value and therefore includes a considerable factor of safety.

5. CONSTRUCTION OF THE PROPOSED MODEL

5.1. Location

The location of site is 29°1'13.70" N and 79°29'32.64" E i.e. near the rear entrance of the Department of Civil Engineering, College of Technology, GB Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India.

5.2. Materials

The materials used are as follows:

Sno.	Particular (Item Name)
01.	Machine molded perforated bricks
02.	Cement Concrete
03.	Hollow MS square sections
04.	Paints
05.	UPVC pipes (200 mm dia)
06.	Plastic boxes
07.	Hollow GI pipes (50mm dia)

5.3. Procedure

The process involved the selection of the site. The site was so selected that it stood in vicinity of Departmental Laboratories and as an area where the subsurface is been largely undisturbed. Such a land of dimension 8’ x 8’ was obtained under due permission from the pertinent department. The entire construction process started with the excavation of the foundation from mechanical means up to a depth of 2.5’. The depth was adequate enough for the water table to interfere and was evidently observed when the water started seeping into the pits. In order to counteract the weathering affect of water on the base of the column footing, we used plastic boxes of diameter 12’’ at the top with tapering so that the bottom diameter of the box was nearly 8’’. The boxes were introduced and placed firmly into the pits followed by an initial concreting of 6’’ over which the hollow pipes were placed and fixed until initial setting time. The concreting operations involve the usage of 1-1.5-3 concrete mix. It was followed by concreting of the columns with the introduction of hollow GI pipes of 50mm diameter which were lying as a waste in the hydraulics laboratory. In order to make the pipes of the required length, the process of welding was employed and extra portion was removed using a machine saw. The usage of hollow GI pipes instead of conventional steel bars signified economy in our construction process. The next task undertaken was the brickwork enclosing the model. The height given above the ground level was nearly 1’ and nearly 0.5’ beneath the ground level. The final work involved the placement of truss as shown earlier over the UPVC columns. The truss obtained after welding was connected with the help of MS rectangular strips on top of the column so that the entire load is evenly distributed on the entire cross section of the column. The other conception in the idea was to paint the columns black over which a coat of white is done in order to maximize the reflectance of ultra violet rays thus increasing the durability. The final structure obtained is as shown below.

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6. RESULTS AND DISCUSSIONS

After analysis the truss, different forces at joints are obtained with the help of STAAD Pro. The results show that the axial load is much less than the maximum permissible strength of column. Now using IS 456:2000, concrete column section is designed. Section of column is designed such that it can transfer the load safely to the foundation. It is further observed that the strength of the column is increased approximately by *10 %* due to confinement by UPVC tubular sections. It is found that UPVC tubes can be effectively used for confinement of the concrete columns and to enhance their load capacity, ductility as well as energy absorbing capacity.

7. CONCLUSION

Nowadays a number of polyhouses are being constructed and there is a need to have a proper design of structural members to make the polyhouse safe and economical depending upon the site condition where it is to be constructed. So with the help of this study, the farmer can utilize the concept to get the maximum benefit of the safe and economical design with an additional protection from the adverse environmental conditions.

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