

*Research Article*

## Effectiveness of Cold Formed Steel Storage Water tank

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### Abstract

*Cold formed steel have numerous advantages over other conventional materials as structural components like light weight, high strength & stiffness, easy installation & construction, durable, economical in transportation & handling. In India, Cold formed steel usage is booming due to above mentioned advantages. The concept of cold-formed light steel framing construction has been widespread after understanding its structural characteristics with massive research works over the years. Connection serves as one of the important elements for light steel framing in order to achieve its structural stability. Compared to hot-rolled steel sections, cold-formed steel connections perform dissimilarly due to the thin-walled behaviour. This paper aims to review current researches on cold-formed steel for Water tank. The performance of these water tanks with the design of cold-formed steel panels will be analyzed for various shapes at various heights and the most optimum design geometry & panel will be arrived at using the AISI code for cold formed steel.*

**Keywords:** Cold Formed Steel, Water tank, hydrostatic pressure

### 1. Introduction

In building construction, cold-formed steel products are mainly used as structural members, diaphragms, and coverings for roofs, walls and floors. There are varieties of cold-formed shapes available as structural members, which include open sections, closed sections, and built-up sections. Cee-, zee-, double channel I-sections, hat, and angle sections are open sections while box sections and pipes are closed sections. The built-up members are formed by connecting two or more cold-formed steel members together, such as an I-section member built up by connecting two channel sections back-to-back. These structural shapes can be used in buildings as eave struts, purlins, girts, studs, headers, floor joists, braces, and other building components. Various shapes are also available for wall, floor, and roof diaphragms and coverings. Since cold formed steel is widely used in buildings as structural system, it can be effectively used as structural member in water tanks.

This paper aims to determine the effectiveness of using cold formed steel water tanks. The water tank structure will be designed in STAAD Pro software with the help of AISI & ASCE 7-10 codes. The findings from this project will provide a rational approach to the design of these structural components based on thorough understanding of their behavior under lateral (hydrostatic or wind) loading and therefore will be considered to produce optimum and safe structures.

### 2. Procedure

#### *Design factors*

Water Tank Construction technology using CFS members is a new venture. The model of Water tank of size 10m long x 4m wide x 4m high at Speed House Factory Location is analyzed by using existing information. It is seen that some of the members are failed in Design calculations hence this study is carried to arrive at the best optimized and economical system for water tank.

Various cases have been developed by using different types of material configurations for walls. The Roof members and Base member are kept with same arrangement all systems. Wall member is designed for hydrostatic pressure, Base Frame is design for base pressure and roof member is design for dead load, live load and tension force.

#### *Cases being done are as follows*

- 1) Existing water tank review
- 2) Vertical Open Webbed With Linear Roof Cap and Linear Base Frame
- 3) Vertical Linear stud With Linear Roof Cap and Linear Base Frame

#### *Scope of work*

Develop a CFS Water Tank and Support system for Water Tank Housing. Various options are reviewed,

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studied and analyzed to come up with the most cost effective system.

**Building Codes**

- IBC 2009 - International Building Code
- ASCE 7-05 - Minimum Design Loads For Buildings & Other Structures
- ACI318-05 - Building Code Required For The Structural Concrete
- AISI 2007 – North American Specifications for design of structural members

**Structural Requirements**

The walls panels, Base are all made up of cold formed steel sections shall be produced from pre-galvanized steel coils in accordance with ASTM A653-11. Structural steel SS Grade 55 or Grade 80 as per ASTM A653- 11 shall be used.

The CFS framing members are hot-dipped galvanized with a G90 coating as per code ASTM A653. The structural and non structural members shall comply with minimum metallic coating of G60 and G40 respectively. Alternative coatings shall be permitted to be used if proven to be equivalent.

**Structural Outputs**

- 1) Approach Document
- 2) Design elements
  - a. Design of Roof Main Member
  - b. Design of Roof Nogging Member
  - c. Design of Wall Main Member
  - d. Design of Wall Nogging Member
  - e. Design of Base Main member
  - f. Design Of Base Nogging Member
  - g. Design of Base Foundation
- 3) Material Analysis Summary Excel for decision Parameters and comparative results

**Loading**

- Gravity Design Loading
- Roof Load
- Dead Load=0.5 kPa (10.44 psf)
- Live Load =1.0 kPa (20.89 psf)
- Floor Base Load
- Dead Load =1.0 kPa (20.89 psf)
- (Sheathing & water-proofing material)
- Live Load =1.0 kPa (20.89 psf)
- Specific Weight of Water = 1.0 kPa (20.89 psf)
- Water Tank Wall Load
- Wall Dead Load=1.0 kPa (20.89 psf)
- Hydrostatic Pressure= 39.24 kPa(819.54psf)....For 4m Height

**Materials**

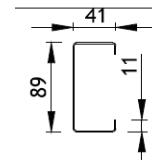
Cold Formed Steel

The CFS section will be 89 mm with 0.75mm, 0.95mm, 1.15mm and 1.45mm thick with G350 or G550 strength Or 140mm with 1.45mm, 1.8mm.

**Used Section 89S41 and Thickness varies from 0.75mm to 1.45mm**

**Used Section 140S41 and Thickness varies from 0.75mm to 1.45mm**

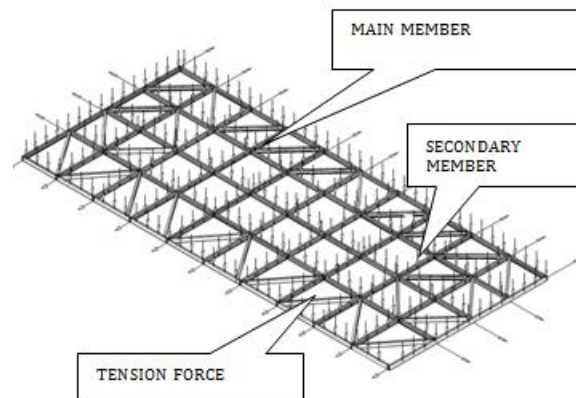
**Used Section 140S41 and Thickness varies from 1.45mm to 1.8mm**



**Water Tank Design Approach and Calculation**

**Design of Roof Framing**

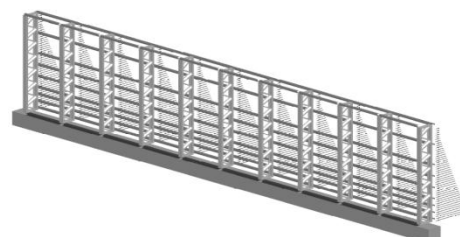
The Roof Frame is made up of CFS members arranged as main member and Secondary member are designed for the Dead load and live Load and check for Bending, Shear, Deflection and tension capacity which comes from hydrostatic pressure on wall.



**Fig 2: Water tank Roof frame**

**Design of Wall Panels**

The Containment panels are made of CFS members. These are designed for resisting Water Pressure (from top to bottom).



**Fig 3: Water tank Wall frame**

Design of Base Framing

The Base Frame is made up of CFS members arranged in Grid pattern and are designed for the vertical (Gravity) loads/pressure from the self weight of tank and weight of water (assuming water is filled to the maximum allowed height).

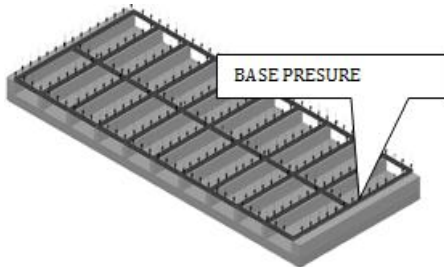


Fig 4: Water tank Base frame

Design of Base Foundation and Slab

The Foundation for the Water Tank will be composed of concrete stem walls spaced at every 1m resting on transfer slab for proper load transfer. The load from the Water Tank is transferred to the Foundation through the Base Frame and the foundation is designed for load transferred from the base frame.

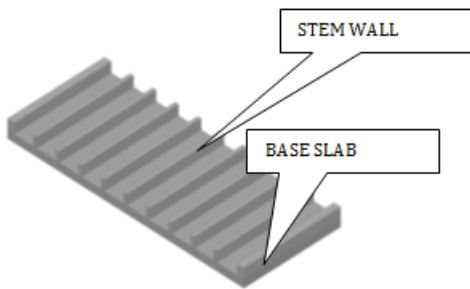


Fig 5: Water tank foundation

Deflection Criteria

Vertical Member

Total Load =  $L/600$

Live Load =  $L/600$

Base Frame and Cap

Total Load =  $L/600$

Live Load =  $L/600$

Three Main Cases

Water Tank design is carried out for different cases as shown below.

- 1) Existing water tank review
- 2) Vertical Open Webbed Joist With Linear Roof Cap and Linear Base Frame
- 3) Vertical Linear member with Linear roof cap and Linear bas frame.

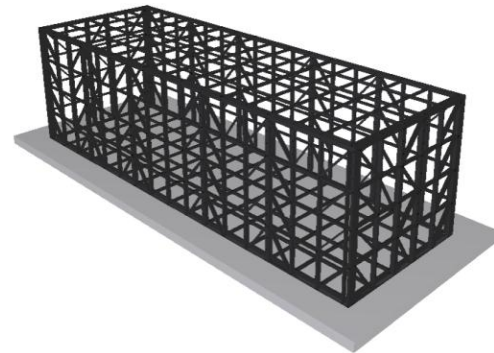


Fig 4: Water tank linear wall member

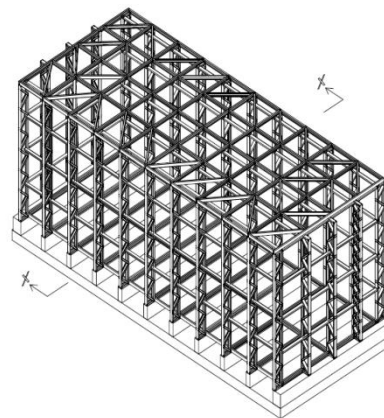


Fig 4: Water tank webbed wall member

3. Results

There are seven cases in all with existing case, vertical linear member + linear roof cap + linear base frame, vertical linear stud + linear roof cap + linear base frame

Description of cases

Table 1: Description of cases

Cases	Type of vertical wall member	Description	Remark
Case 3		1 width 2m x height 2m x length 10m	good with small height
Case 4	VERTICAL LINEAR MEMBER WITH LINEAR ROOF CAP AND LINEAR BASE FRAME	2 width 2m x height 3m x length 10m	higher weight
Case 7		3 width 3m x height 2m x length 10m	good with small height
Case 8		4 width 3m x height 3m x length 10m	higher weight
Case 1		5 width 4m x height 4m x length 10m	higher weight
Case 5	WEBBED WALL MEMBER WITH LINEAR ROOF CAP AND LINEAR BASE FRAME	1 width 2m x height 3m x length 10m	Optimized
Case 6		2 width 2m x height 4m x length 10m	Optimized
Case 2		3 width 4 x height 4m x length 10m	Most optimized

Tabular Representation

Table 2: Results for cases based on parameters

Cases	Width x Height	Wall Member	Width (m)	Height (m)	Deflection (mm)	Moment (kNm)	Shear Z (kN)	Weight in kN	Plan Area (m <sup>2</sup> )	Weight/Area (kN/m <sup>2</sup> )	Volume (m <sup>3</sup> )	Weight/Volume (kN/m <sup>3</sup> )
Case3	2X2	Linear	2	2	5.37	2.40	1.67	9.36	20.00	0.47	40.00	0.23
Case4	2X3	Linear	2	3	31.82	6.74	2.70	17.47	20.00	0.87	60.00	0.29
Case5	2x3	Webbed	2	3	4.97	0.40	6.51	11.96	39.00	0.40	60.00	0.20
Case6	2X4	Webbed	2	4	11.15	0.72	8.39	21.58	20.00	1.08	80.00	0.27
Case7	3X2	Linear	3	2	2.13	4.74	1.67	15.74	30.00	0.52	60.00	0.26
Case8	3X3	Linear	3	3	26.53	6.74	2.71	22.95	30.00	0.76	90.00	0.25
Case1	4x4	Linear	4	4	15.4	37.76	49.053	33.2	40.00	0.83	160.00	0.21
Case2	4x4	Webbed	4	4	9.44	3.90	22.145	29.7	40.00	0.74	160.00	0.19

Graphical representation

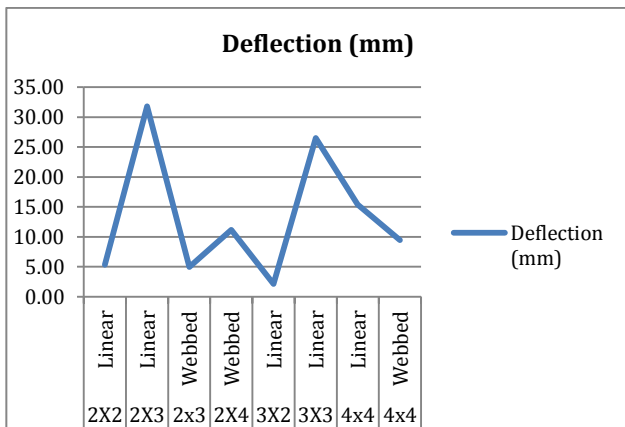


Fig 24: Graph for deflection in mm against each case

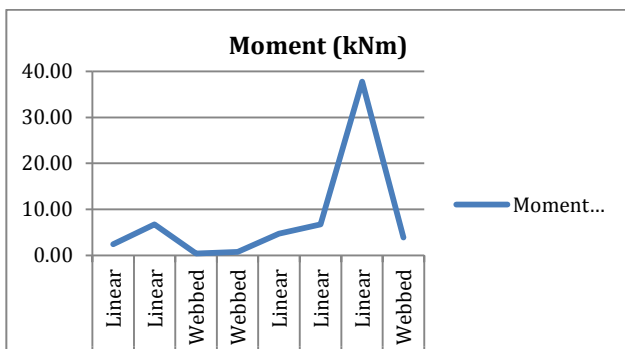


Fig 24: Graph for moment in kNm against each case

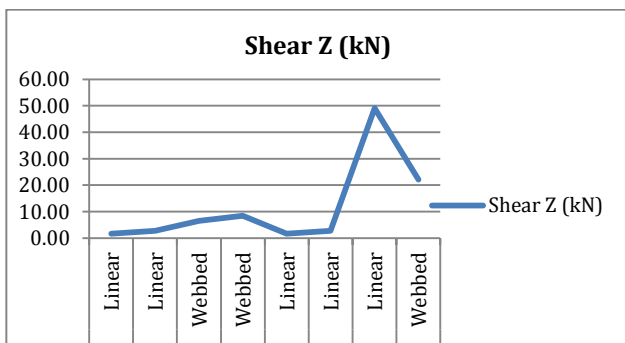


Fig 24: Graph for Shear in kN against each case

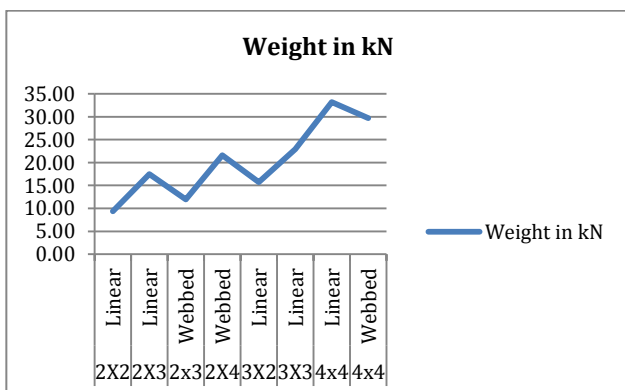


Fig 24: Graph for weight in kN against each case

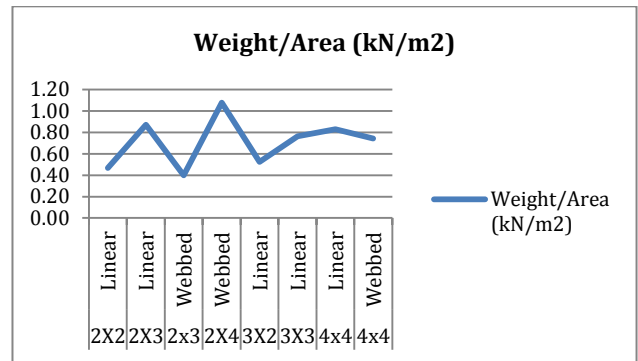


Fig 24: Graph for weight per area in kN/m<sup>2</sup> against each case

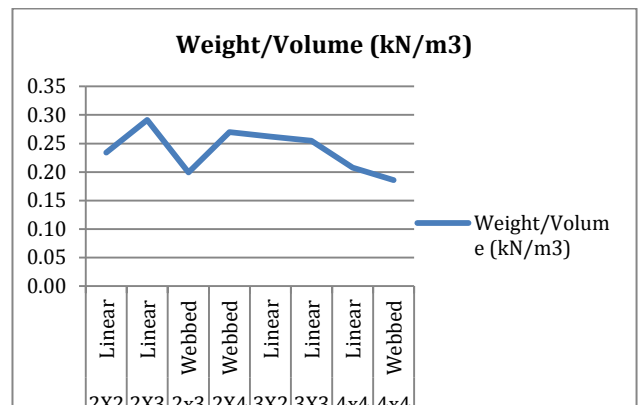


Fig 24: Graph for weight per volume in kN/m<sup>3</sup> against each case

Conclusion

The purpose of this study was to evaluate the feasibility of using cold formed steel as structural element in water tanks resting on ground. To study, seven cases of water tank with different member arrangement was modelled and analysed in STAAD Pro.

Based on the results of the investigation, the following findings and conclusions are presented for cold formed steel water tanks resting on ground:

- The weight per meter for the different water tanks in CFS increases with increase in height of water tank.
- For smaller dimensions of water tank, vertical linear member are efficient when compared to webbed joist vertical members.
- For larger dimensions of water tank, large vertical linear member are required. However if webbed truss members of smaller sections are used, the weight per square meter is less when compared to linear vertical members. But this result also varies depend on spacing of the vertical members. Larger vertical linear members with more thickness spaced wider would result in economical water tank
- When compared to Hot rolled steel, there is a drastic difference in weight of tank. Cold formed steel reduces the weight of tank considerably thereby being economical.

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