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Design of a frame structure for tractor operated mulch laying equipment using in crop mulching operations

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Abstract
This study was involved in the design of the frame structure for the tractor operated mulch laying equipment. Basically the mulching used for the making the plant favourable conditions for the growth and the conservation of the moisture content with the uniform maintenance of the soil temperature. The weed can be controlled greatly and mulch system develops the efficient crop production .This paper deals with the design of frame structures sustainability for the given loads and stresses developed while operating a equipment in the fields. Tractor operated mulch laying model was developed basically to fulfil the purpose of the laying of the mulch sheets such as plastic LDPE films as well as bio-degradable sheets. It has been found that the buckling loads of the frame as 98721N and the torque transmitted by the frame with the welded joints of the frame was 2821630.53 N-mm and the conclusions were made like that the input loads in the equipment was 3335.4 N and the frame structure sustainable loads were 98721N, so the equipment was safe against the buckling loads generated in the equipment while in operation in fields. The developed equipment has been found that a farmer can easily operate and then the economical point of view a normal farmer can offer this price.

Keywords: Plastic mulch, mulching machine, design of frames, mulch laying equipment frames design

Introduction
In the early 192's the paper mulches were used in the agricultural fields for the production of the vegetables and etc, but later on it has been found that the life of the paper mulch was very [1] short and then the trend was went towards the polymer mulches such as the polyethylene films, foil waxes and petroleum and resin, mulches were also developed.

Specifically, mulching with organic or inorganic materials aims to cover the soils and forms a physical barrier to limit the evaporation of water from the soil, automatic control of weeds, preserve a good soil structure, and protecting the crops from soil contamination. Naturally available mulches are those derived from animal and plant materials, if they are used accurately; they can proffer all the advantages and profits of other types of mulches available. Natural mulches help in maintaining soil organic matter and provide food and shelter for earthworms and other desirable soil biota [2, 3].

Materials and Methods
Selection of material: Selection of the Material was done with the Product Range Available in Tata Structure Square Hollow Sections based on the Market survey by considering the availability of material in the market. Table 1 show the properties of selected material of square hollow section (SHS) and product range: Square Hollow Sections (SHS) respectively.

Table 1: TATA steel hollow pipes properties

Properties of Tata Structura (Square Hollow Sections) YST 310 Grade

SHS B x B mm	Thickness mm	Sec Area A cm^2	Unit W Kg/m	Moment of Inertia		Radius of Gyration		Elastic Modulus		Torsional Constants		Outer Surface
				I_{xx}, cm^4	I_{yy}, cm^4	r_{xx} cm	r_{yy} cm	Z_{xx}, cm^3	Z_{yy}, cm^3	J cm^4	B cm^3	Area per m m^2
25x25	2.00	1.74	1.36	1.48	1.48	0.92	0.92	1.19	1.19	2.29	1.68	0.090
	2.60	2.16	1.69	1.72	1.72	0.89	0.89	1.38	1.38	2.68	1.92	0.087
	3.20	2.53	1.98	1.89	1.89	0.86	0.86	1.51	1.51	2.96	2.07	0.084
32x32	2.00	2.30	1.80	3.36	3.36	1.21	1.21	2.10	2.10	5.30	3.05	0.118
	2.60	2.88	2.26	4.02	4.02	1.18	1.18	2.51	2.51	6.45	3.63	0.115
	3.20	3.42	2.69	4.54	4.54	1.15	1.15	2.84	2.84	7.41	4.07	0.112
38x38	2.60	3.51	2.75	7.14	7.14	1.43	1.43	3.76	3.76	11.51	5.49	0.139
	3.20	4.19	3.29	8.18	8.18	1.40	1.40	4.30	4.30	13.45	6.28	0.136
	4.00	5.03	3.95	9.26	9.26	1.36	1.36	4.87	4.87	15.67	7.12	0.131
40x40	2.60	3.72	2.92	8.45	8.45	1.51	1.51	4.22	4.22	13.63	6.20	0.147
	3.20	4.45	3.49	9.72	9.72	1.48	1.48	4.86	4.86	16.00	7.12	0.144
	4.00	5.35	4.20	11.07	11.07	1.44	1.44	5.54	5.54	18.75	8.12	0.139
50x50	2.60	4.76	3.74	17.47	17.47	1.92	1.92	6.99	6.99	28.53	10.37	0.187
	2.90	5.25	4.12	18.99	18.99	1.90	1.90	7.60	7.60	31.15	11.23	0.185
	3.60	6.35	4.98	22.15	22.15	1.87	1.87	8.86	8.86	36.58	12.98	0.181
	4.50	7.67	6.02	25.50	25.50	1.82	1.82	10.20	10.20	41.99	14.68	0.177
60x60	2.60	5.80	4.55	31.33	31.33	2.33	2.33	10.44	10.44	50.08	15.52	0.227
	3.20	7.01	5.50	36.94	36.94	2.30	2.30	12.31	12.31	60.02	18.31	0.224
	4.00	8.55	6.71	43.55	43.55	2.26	2.26	14.52	14.52	72.41	21.62	0.219
	4.80	10.01	7.85	49.22	49.22	2.22	2.22	16.41	16.41	83.86	24.51	0.215
72x72	3.20	8.54	6.71	66.32	66.32	2.79	2.79	18.42	18.42	106.81	27.47	0.272
	4.00	10.47	8.22	79.03	79.03	2.75	2.75	21.95	21.95	129.85	32.78	0.267
	4.80	12.31	9.66	90.31	90.31	2.71	2.71	25.09	25.09	151.55	37.55	0.263

The selected square pipe dimensions are as follows

The Exterior breadth B = 50 mm & The Exterior height, H = 50 mm	The Interior breadth, b = 46 mm & The Exterior height, h = 46 mm	Thickness of pipe = 2.6 mm

Determination of Buckling Load on the frame: [4]

$$Wcr = \frac{\Pi^2}{L^2}\frac{E*I}{},$$

Where,

E = young's Modulus of the steel pipe, E= 210000 N/mm^2

I = Moment of Inertia, mm^4

L = Length of the pipe, mm

$$Wcr = \frac{(3.14)^2}{}\frac{*210000*147712}{1760^2} = \frac{(3.058*10)^{11}}{1760^2} = 98721 \text{ N}$$

The Strength of the welded joints: To find out the strength of the welded joints, it was necessary to know the properties of the welding materials. The E7108 welded rods were used for the joining the pipes and the this materials properties were like this as follows:

The tensile strength is 582 N/mm2 and the Yield Strength is 479 N/mm2.

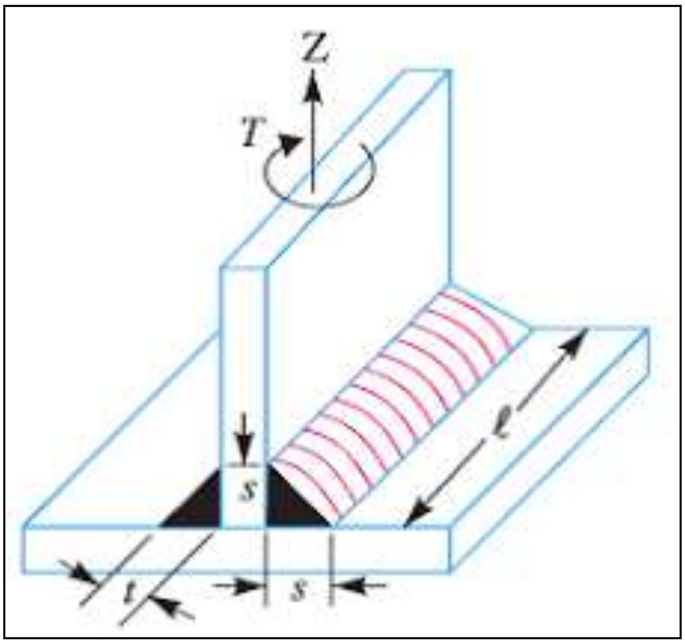


Fig 1: Torque Transmitted by the welded joints

The above figure shows the welded joints when subjected to torque, the strength of the joints can be calculated by considering the torque.

Where,
T = Torque acting on the vertical pipe, N-m
l = length of the weld, mm
s = size of the leg or weld, mm
t = Throat Thickness, mm

Shear Stresses,

$$\tau = \frac{3*T}{t*L^2}$$

Where,
T = Torque acting on the vertical pipe, N-m
l = length of the weld, mm
s = size of the leg or weld, mm
t = Throat Thickness, mm

The maximum yield strength as per properties of Electrode E7018 was 479 N/mm^2

As per the above equations

$$479 = \frac{4.242 * T}{10mm * 50^2}$$

$$479 * 10 * 2500 = 4.242 * T$$

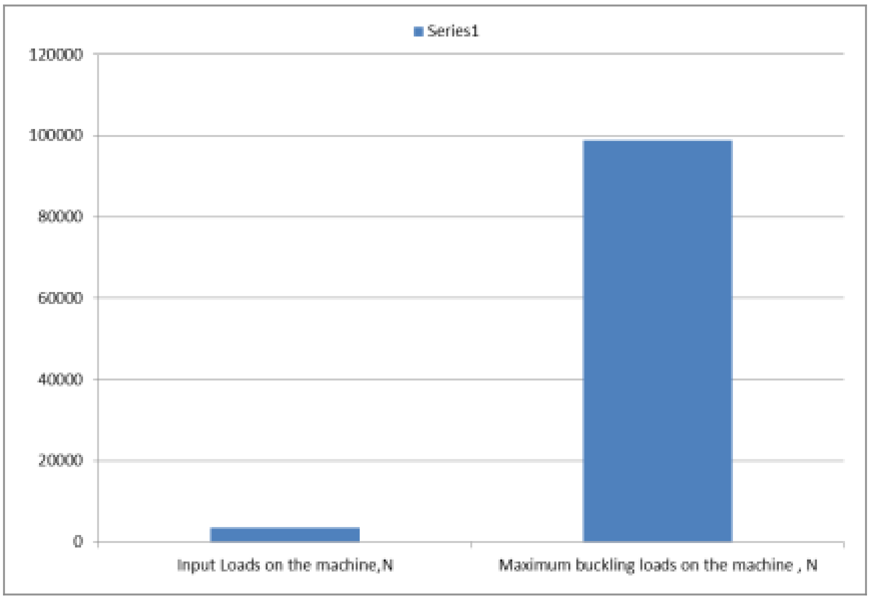
$$T = \frac{479 * 10 * 2500}{4.242} = 2821630.53 \text{ N-mm}$$

$$= \frac{3*T}{t*L^2} = \frac{3*2821630.53}{8mm*50^2} = \frac{84648915}{20000} = 4232.4 \text{ N/mm}^2$$

Results and Discussion:

Table 2: The input and maximum bearable load capacity of the frame

S. No.	Input Loads on the machine, N	Maximum buckling loads on the machine, N
1	3335.4	98721



Graph 1: Input load vs Maximum buckling loads on the welded joints

The Input load of the machine due to self-weight was 3335.4 N but the buckling load was calculated was 98721 N which is greater than the input load so, the frame was safe

The welded joints strength was calculated in terms of the torque that can be allowed by the joints was 2821630.53 N-mm but the input torque generated by the main shaft and counter shaft was 883682.3 N-mm and 875542.5 N-mm respectively. Hence, the maximum torque generated in the machine frame was greater than the input torque and the stresses developed in the machine was calculated as 4232.4 N/mm^2 which was against the yield strength of the electrode materials was 479N/mm^2

So, the maximum buckling loads and the developed stresses in the machine was concluded as follows:

Table 3: The maximum buckling loads and the stresses in the frame

S. No	Component	Value with Units
1	Maximum Buckling load of the frame	98721 N
2	welded joint strength: developed Stresses	4232.4 N/mm^2

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