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Comparative Analysis Of Cellular Beam And Honeycomb Beam With Anasys Program

Alvin Hogan M. Situmorang

Department Of Civil Engineering, University Of North Sumatra, Jl. Dr. Mansur No. 9 Padang Bulan, Kec. Medan Baru, Kota Medan 20222

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ABSTRACT

Steel is one of the most widely used construction materials. Along with the development of technology in the field of construction, many variations have been made in the use of steel as a construction material to make it more suitable for the needs and economical in terms of cost. One of the innovations that is often used in steel is to make holes in the body to increase the height of the steel profile. The shape of the hole that is usually formed on the body varies. The most frequently used variations are the hexagon shape (honeycomb beam) and the circular beam (cellular beam). In this study, we will compare the honeycomb beam and the cellular beam. The two beams will be made in several variations with D/Do and S/Do parameters. The experiment was carried out using the ANSYS program. Comparisons are made to find a beam that has a better ability than the parameter variations on the two beams From the results of the study, it was found that the best parameter variations were D/Do = 1.6 and S/Do = 1.08 for honeycomb beam. For cellular beam D/Do = 1.6 and S/Do = 1.28 which is better. Then from the comparison of cellular beam and honeycomb beam, it is found that the honeycomb beam is better.

Corresponding Author:

Alvin Hogan M. Situmorang ,
Department Of Civil Engineering,
University Of North Sumatra,
Jl. Dr. Mansur No. 9 Padang Bulan, Kec. Medan Baru, Kota Medan 20222.
Email : alvinsitumorang@gmail.com

1. INTRODUCTION

Nowadays, steel construction is an alternative in the construction of buildings or other structures, both on a small and large scale. Therefore, steel is widely used for structures with the type of height, width and other types of structures. So that with the development of technology and the increasing need for the use of steel in structures, scientists make innovations to increase the strength of steel at a more economical price.

A planner in planning a structure must not only consider the safety and serviceability of the structure, but he must also consider the functional requirements based on the use of the building structure. When planning a structure in a high-rise building, the conventional steel structure consists of beams and girders with steel whose body parts are still solid. This makes it difficult for the placement of pipes, ducts and air conditioners that require functional satisfaction for their location in the structure. As a result of this, the scientists developed a system of openings in the steel body to facilitate installation services and also to maintain the installation on a regular basis and for a long period of time.

Steel with openings in the body is profile I steel which is made by cutting the standard profile body into 2 parts along the span, then separated, shifted and welded back into a new shape (JP Boyer, 1964). The result of this process makes the steel profile has a higher height than the beginning, resulting in the addition of inertia. As the inertia increases, the strength of the steel increases. The economic value of the I profile can be increased, because the initial I profile with smaller dimensions and lighter weight can be formed into a profile that has a higher height. The shape of the opening in the steel body will depend on the designer's choice and the desired opening. There is no fixed rule to govern the shape of an existing opening. But for the convenience of the planner, prefer to use openings with a symmetrical shape. Steel beams with openings are usually called castellated beams. There are several forms of openings in steel that are usually used such as honeycomb beams with hexagon-shaped openings and cellular beams with circular openings.

2. RESEARCH METHOD

The research method used in this final project is a literature review method in which the required data are assumed to be based on field conditions. The following is the sequence of this research:

a. Looking for basic literature describing cellular beam, honeycomb beam and ANSYS
b. Basic discussion about the advantages of cellular beam and honeycomb beam.
c. Plan IWF into cellular beam and honeycomb beam, then perform analysis using ANSYS.
d. Processing the data obtained by ANSYS, then making comparisons to the cellular beam and honeycomb beam.

This research is an experimental experiment on several forms of variation of openings in the steel profile body. In this research, two applications are used. The first application is SolidWorks which is only used to simplify the process of drawing steel profile models with openings in the body. The next application is ANSYS to analyze the ability of steel profiles that have openings in the body.

The test object that is planned and analyzed in this research is a steel profile that is formed in such a way that it has openings in its body. There are two types of openings in the body that will be analyzed in this study, namely cellular beam (opening with a circular shape on the body) and honeycomb beam (opening with a hexagon shape on the body). At each opening in the body, several different variations will be planned following several parameters. The parameters used to make variations are the height of the opening in the steel profile body and the distance between the center point to the center point of the opening in the steel profile body. Each variation will be done the same for the cellular beam and honeycomb beam.

The research was carried out on steel profiles with openings in the body that functioned as beams. The supports used in the beam are simple supports (beams with joint and roller supports). The beam is given a concentrated load at the center of the span. The span length of the beam elements for the cellular beam and honeycomb beam to be analyzed is the same length for each variation of the modeling of the two beams. From the results obtained from the analysis will be compared the deflections and stresses that occur. The flow chart below will explain in general the process of doing this research from beginning to end.

3. RESULTS AND DISCUSSIONS

3.1 Experimental Data

The following are the results of the data obtained from ANSYS for each variation carried out. The first table below is a table of results from the initial profile.

Table 1. Data Table of Initial Profile Results

	WF 400X200	
Style (N)	Voltage (MPa)	Deflection(mm)

5000	14.98	2.0578
10000	29.946	4.1158
15000	44,896	6.1741
20000	59,832	8.2325
25000	74.753	10,291
30000	89,659	12.35
35000	104.55	14,409
40000	119.43	16,469
45000	134.29	18,528
50000	149.14	20.588
55000	163.97	22,648
60000	178.79	24.708
65000	193.59	26,768
70000	208.38	28.828
75000	223.18	30.9
80000	237.92	32,952
85000	252.67	35,013
90000	267.4	37,074
95000	282.12	39,135
100000	296.84	41,197
105000	249.55	43,268
110000	249.76	45,354
115000	249.92	47,459
120000	250.09	49,586
125000	250.25	51,802
130000	251.1	54.579
135000	252.91	59,045
140000	257.9	72,764
145000	.>error	

a. Model 1

Table 2. Results Data Table (Model 1)

	Model 1 (S/Do = 1.28 ; D/Do = 1,4)			
Style (N)	Cellular Beam		Honeycomb Beam	
	Voltage (MPa)	Deflection(mm)	Voltage (MPa)	Deflection(mm)
5000	11.03	1.0838	10,616	0.98523
10000	22.05	2.1677	21,242	1.9705
15000	33,059	3.2517	31,878	2.9559
20000	44,059	4.3357	42.523	3.9413
25000	55,048	5.4198	53,178	4.9268
30000	66.028	6.504	63.843	5,9123
35000	76,997	7.5882	74.517	6,898
40000	87,957	8.6725	85,202	7.8836
45000	98,906	9.7569	95.896	8.8694
50000	109.85	10,841	106.6	9.8552
55000	120.78	11,926	117.31	10,841
60000	131.7	13,011	128.04	11,827
65000	142.61	14,095	138.79	12,811
70000	153.51	15.18	149.51	13.8
75000	164.4	16,265	160.26	14.786
80000	175.28	17.35	171.03	15,774
85000	186.15	18,435	181.81	16,762
90000	197.01	19.52	192.6	17,752
95000	207.86	20.605	203.4	18,743
100000	218.7	21.69	214.21	19,736
105000	229.54	22.775	225.04	20.731
110000	240.36	23.86	235.88	21,728
115000	251.17	24,946	246.73	22,728
120000	261.98	26,032	257.6	23,731
125000	272.81	27.12	268.52	24,738
130000	265.38	28,212	271.84	25,748
135000	273.37	29,311	272.23	26,764

140000	275.91	30,418	280.47	27,786
145000	267.52	31,536	264.16	28.817
150000	267.36	32,672	262.35	29,858
155000	255.62	33,826	267.25	30,912
160000	248.47	35,011		
165000	248.51	36,238		
170000	248.5	37,579	>error	
175000	248.91	39,316		
180000	249.75	41,995		
185000	>error			

b. Model 2

Table 3. Results Data Table (Model 2)

Model 2 (S/Do = 1.28 ; D/Do = 1.5)				
Style (N)	Cellular Beam		Honeycomb Beam	
	Voltage (MPa)	Deflection(mm)	Voltage (MPa)	Deflection(mm)
5000	11,346	1.1096	10.86	1.0197
10000	22,682	2.2193	21.71	2.0395
15000	34.006	3,329	32.55	3.0593
20000	45.32	4.4389	43,381	4.0792
25000	56.623	5.5488	54,203	5.0992
30000	67,915	6.6588	65,015	6.1193
35000	79,196	7.7688	75.819	7.1394
40000	90,467	8.879	86.612	8.1596
45000	101.73	9.9892	97.397	9.1799
50000	112.98	11.1	108.17	10.2
55000	124.22	12.21	118.94	11.221
60000	135.44	13.321	129.69	12,241
65000	146.49	14,492	140.44	13,261
70000	157.87	15.54	151.18	14,283
75000	169.07	16,651	161.91	15,303
80000	180.25	17,762	172.63	16,325
85000	191.43	18,873	183.35	17.347
90000	202.6	19.984	194.05	18,369
95000	213.75	21,095	204.75	19,393
100000	224.9	22.206	215.44	20,417
105000	236.03	23,317	226.12	21.442
110000	247.16	24,428	236.8	22,469
115000	258.27	25.539	247,47	23,498
120000	269.37	26,651	258.13	24,529
125000	270.72	27,763	268.83	25.562
130000	273.88	28.878	268,78	26,599
135000	277.04	29.9996	272.23	27,641
140000	267.78	31,12	276.4	28,688
145000	260.97	32.252	265.79	29,743
150000	254.88	33,395	266.83	30,806
155000	256.9	34,552	258.44	31.88
160000	248.3	35.73	254.25	32,968
165000	248.34	36,948	248.11	34,077
170000	248.37	38,306	248,12	35,241
175000	248,88	40,096	248.27	36,578
180000	249.97	42,758	248.87	38,322
185000	>error		249.59	40,958
190000			>error	

c. Model 3

Table 4. Results Data Table (Model 3)

Model 3 (S/Do = 1.28 ; D/Do = 1.6)				
Style (N)	Cellular Beam		Honeycomb Beam	
	Voltage (MPa)	Deflection(mm)	Voltage (MPa)	Deflection(mm)

5000	10,922	1.1576	11,112	1.0673
10000	21,836	2.3152	22.215	2.1346
15000	32.74	3,473	33.308	3,202
20000	43,636	4.6308	44,392	4.2695
25000	54.523	5.7887	55,466	5.3371
30000	65.4	6.9466	66,531	6.4047
35000	76.269	8.1047	77,587	7.4724
40000	87,129	9.2628	88,633	8.5402
45000	97.98	10,421	99.67	9.6081
50000	108.82	11,579	110.7	10,676
55000	119.66	12,738	121.72	11,744
60000	130.48	13,896	132.73	12,812
65000	141.3	15,056	143.73	13,881
70000	152.1	16,213	154.72	14.948
75000	162.9	17,372	165.7	16.017
80000	173.69	18,531	176.67	17.085
85000	184.47	19.69	187.64	18,154
90000	195.25	20.849	198.59	19,222
95000	206.01	22.008	209.54	20,291
100000	216.77	23,167	220.48	21.36
105000	227.52	24,326	231.41	22.43
110000	238.25	25,485	242.33	23.5
115000	248.99	26,644	253.25	24,571
120000	259.71	27,804	264.16	25,643
125000	258.95	28,966	272.85	26,717
130000	268.45	30,13	269.58	27,794
135000	270.29	31,298	278.66	28.875
140000	258.11	32.472	269.68	29,962
145000	263.62	33,655	267.21	31.056
150000	258,68	34,849	259.83	32.157
155000	255.14	36,059	248,48	33,269
160000	248.28	37,294	248.55	34,395
165000	248.37	38,615	248.59	35.572
170000	248.84	40,217	248.61	36.801
175000	249.86	42,362		
180000	251.35	45,916	>error	
185000	>error			

d. Model 4

Table 5. Results Data Table (Model 4)

Model 4 (S/Do = 1.18 ; D/Do = 1.4				
Style (N)	Cellular Beam		Honeycomb Beam	
	Voltage (MPa)	Deflection(mm)	Voltage (MPa)	Deflection(mm)
5000	10,944	1.1343	10.51	0.9865
10000	21,877	2.2686	21,012	1.9731
15000	32,799	3,403	31,504	2.9597
20000	43,712	4,5374	41,988	3.9464
25000	54,614	5.6719	52.463	4.9331
30000	65.505	6.8064	62.93	5.92
35000	76.386	7,941	73.388	6.9069
40000	87,257	9.0756	83.837	7.8938
45000	98,118	10.21	94.277	8.8808
50000	108.97	11,345	104.71	9.8679
55000	119.81	12.48	115.13	10,855
60000	130.64	13.615	125.55	11,842
65000	141.46	14.75	135.95	12,828
70000	152.27	15,884	146.35	13,818
75000	163.07	17.019	156.74	14,805
80000	173.86	18,154	167.12	15,792
85000	184.64	19,289	177.5	16.78
90000	195.41	20,424	187.86	17,769
95000	206.17	21.559	198.22	18,759
100000	216.92	22,696	208.58	19.75
105000	227.66	23,842	218.92	20.743
110000	238.39	25.002	229.26	21,738

115000	249.12	26,181	239.59	22,734
120000	259.85	27,382	249.92	23,732
125000	270.64	28,606	260.24	24,733
130000	271.97	29,861	266.42	25.737
135000	277.41	31,166	266.58	26,747
140000	274.88	32.545	275.64	27,762
145000	269.84	34,035	272.5	28,786
150000	270.39	35,718	263.77	29.82
155000	256.3	37,775	263.71	30,863
160000	248.3	40,837	255.03	31,917
165000	248.4	45.799	250.3	32,993
170000	248.46	52.48	251.4	34,104
175000	248.92	61.343	248.41	35,294
180000			248.72	36,746
185000	>error		249.41	38,766
190000			>error	

3.2 Experimental Data Analysis

At this stage, the data from the experimental results will be analyzed which can be seen in the tables in the previous subchapter. The analysis will be presented in the form of a line graph based on the result data. The analysis will be divided into 3 parts based on the profile height or D/Do parameters.

a. Result Analysis D/Do = 1.4

In this section, a graph of the stresses and deformations that occur due to loading from Model 1, Model 4 and Model 7 will be shown which have the same height with the difference in the distance S.

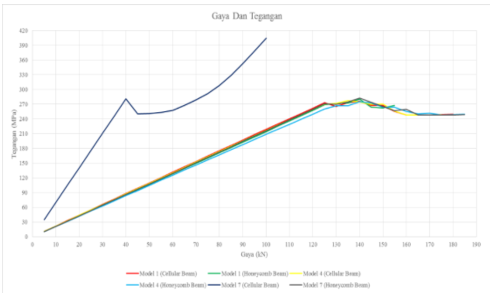

Figure 1. Stress Occurs Due to Loading (D/Do = 1,4)

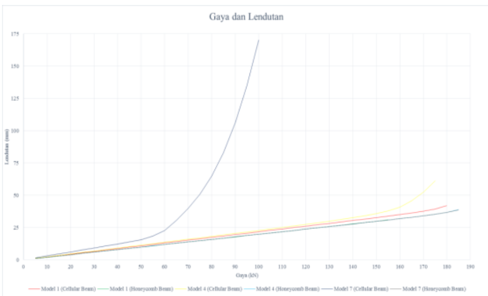

Figure 2. Deflection Occurs Due to Loading (D/Do = 1,4)

The results of the analysis of the graph above:

1) The loading is carried out in stages of 5000 N at each stage until the profile is declared unstable or an error occurs in the analysis carried out by the ANSYS program.

2) From the graph above, it can be seen that the Model 1 Cellular Beam is capable of carrying a load of 180 kN. For the Honeycomb Beam, the load that can be carried by Models 4 and 7 is 185 kN.
3) In Model 7 cellular beam, the smallest load that can be carried is 100 kN. For the honeycomb beam, the smallest load occurs in Model 1 which is 155 kN.
4) The maximum stress that occurs in the cellular beam Model 7 is 404.32 MPa, which is higher than the other models.
5) In Model 1 honeycomb beam the smallest deflection is 30.912 mm when compared to other models.
6) In the cellular beam Model 7, the largest deflection occurs compared to other models, which is 170,29 mm.
7) With the D/Do ratio = 1.4, from the analysis results it can be seen that the S/Do ratio = 1.28 is more suitable for cellular beams. For honeycomb beams, the S/Do ratio of 1.18 and 1.08 is more suitable.
8) When viewed on Model 7, the ratio S/Do = 1.08 is not suitable for use in cellular beam.

3.3 Comparison of Cellular Beam and Honeycomb Beam

In the previous subsection, we have discussed the magnitude of the stresses and deflections that occur due to the gradual loading of the cellular and honeycomb beams. From the data, it can be seen that the load that can be carried by each beam can be seen. However, due to the step of increasing the load every 5 kN, it cannot be seen the final load that can be carried by the beam.

In this section, a re-analysis is carried out to find the load that can be carried by the beam without loading stages on the beam model that has the same load that can be carried. So that the critical load is obtained before ANSYS declares the beam unstable. After knowing the beam that bears the greatest load from several models of cellular beam and honeycomb beam, it will be compared with the initial profile.

The results in the previous subsection, it can be seen that the Model 9 honeycomb beam is a beam that can carry a larger load. For this type of cellular beam, Models 1, 2 and 3 have the same amount of load under gradual loading. Therefore, a re-analysis of the three models was carried out. From the results obtained, the cellular beam Model 3 can carry a larger load.

Table 6. Table of Result Data

Beam Type	Burden	Voltage	Deflection
400 X 200 . Profile	140 kN	257.9 MPa	72,764 mm
Model 3 (Cellular Beam)	184.954 kN	255.16 MPa	56,939 mm
Model 9 (Honeycomb Beam)	195 kN	260.79 MPa	80.946

3.4 Comparison of Bending Stress and Deflection Between Analytical and ANSYS

In this section, we will compare the flexural stresses and deflections that occur due to loading from the results obtained by analytical methods and from ANSYS. The load used is 75 kN. There are 3 points that are reviewed, namely at the top of the profile, middle and bottom. Comparisons were made on the initial profile, Model 3 cellular beam and Model 9 honeycomb beam. The formula used for the analytical method is the formula for moments, flexural stresses and deflections in beams with simple supports which are commonly used.

The deflection that occurs from ANSYS will be reviewed at 3 points, namely at the top, middle and bottom of the cross section. The flexural stresses will be reviewed in the top fiber, center of gravity and bottom fiber, then will be made in the flexural stress diagram. As shown in the following bending stress diagram:

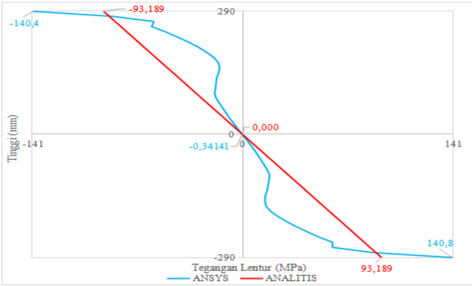

Figure 3. ANSYS and Analytical Bending Stress Diagram for Honeycomb Beam

4. CONCLUSION

From several models based on a variety of parameters, it is found that the ratio of D/Do = 1.6 and S/Do = 1.08 is the largest in carrying the same load for the honeycomb beam. The largest cellular beam is D/Do = 1.6 and S/Do = 1.28.

With the same parameters, the honeycomb beam can carry a larger load than the cellular beam.

In the process of planning honeycomb beams and cellular beams, the D/Do and S/Do parameters greatly affect the performance of the beams. So it must be considered in the planning process.

When viewed from the calculation of the inertia of the cellular beam, for the same height as the honeycomb beam, a smaller inertia will be obtained in the cellular beam. This is due to the wasted part in the cellular beam cutting process. For the larger the distance between the holes, the larger the wasted part on the cellular beam, so the larger the hole diameter and the smaller the inertia. In contrast to the honeycomb beam, the cutting process is simpler and there are no wasted parts in the cutting process.

When viewed from the cellular beam on Models 7, 8, and 9, the ratio S/Do = 1.08 is not very suitable for cellular beam. Because the cellular beam is more rigid to plan the distance between holes, so the distance becomes very small. In contrast to the honeycomb beam, planning the distance between holes can be more easily adjusted.

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