Analyze – College Entrance Structure - Manual calculation (Hardy Cross Method) and by Computer Program (Finite Element Method)

Sandeep Kumar Sharma

HOD (Civil Deptt.), Sri Balaji College of Engineering & Technology, Jaipur.

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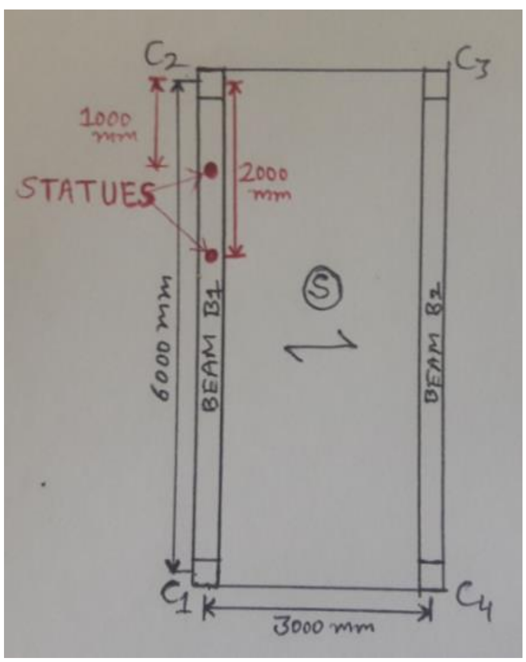
Abstract –The latest trend in structure analysis and design is to use the computer to do all the work as a black box. While doing analysis by software, we don't bother about the theoretical concept. I agree that manual methods are time consuming and tedious but they are prove to be highly useful as they give us a rough idea or say check on the detailed analysis .This paper deal the complete analysis of an entrance porch of a college by moment distribution method and by using software STAAD PRO and comparing results of practically designed entrance porch by me.

Index terms *–Moment distribution method, Stiffness, Carry-Over Factor, Distribution Factor, Sway, Staad- Pro.*

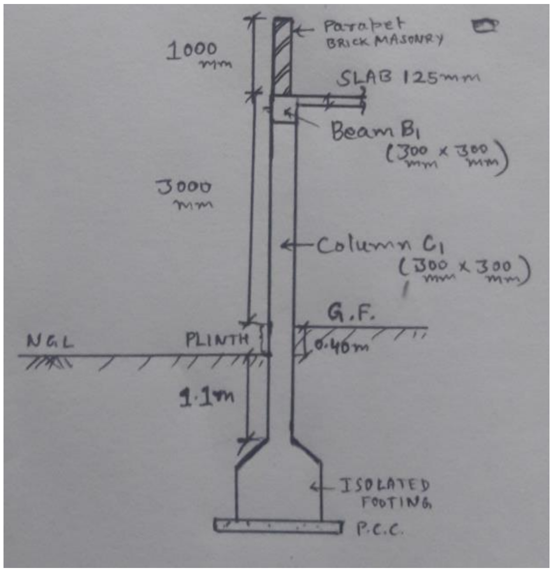
1. INTRODUCTION

Moment distribution method was introduced by Professor Hardy Cross in 1932. This method has remained the most popular method of tackling indeterminate beams and rigid frames. Moment distribution method uses an iterative technique and one goes on carrying on the cycle to reach to a desired degree of accuracy. STAAD PRO is a comprehensive integrated finite element analysis and design solution. The finite element method is a numerical method for solving problems of structural analysis, heat transfer, fluid flow, mass transport etc. Here we analyze an entrance porch of a college building on which two statues of 2500 kg each was fixed.

2. PLAN OF PORCH STRUCTURE



The typical floor plan of entrance porch of area 20.79 sq. m. at college campus is shown above. Part -section show some details of porch structure.



3. CALCULATION OF LOAD

(A)Load per unit area of terrace slab DL LL

R.C.C. slab self weight [3.125 + 0.0] kn/m^2

{ 25KN/m^3 * 0.125m=3.125 KN/m^2}

Water Proofing [2.0 + 0.0] kn/m^2

Floor Finish [1.0 + 0.0] kn/m^2

Live Load [0.0 + 2.0] kn/m^2

Sum = [6.125 + 2.0] kn/m^2

(B) Load taken by Beam B_1 (In our case, it is same for beam B_2)

(i)From slab portion (consider one way distribution) 8.125kn/m^2 * 3m/2 = 12.19 kn/m

(ii)Beam self weight = 4.0 kn/m

{25kn/m3*0.4m*0.4m}

Total Load (w) =16.19 kn/m

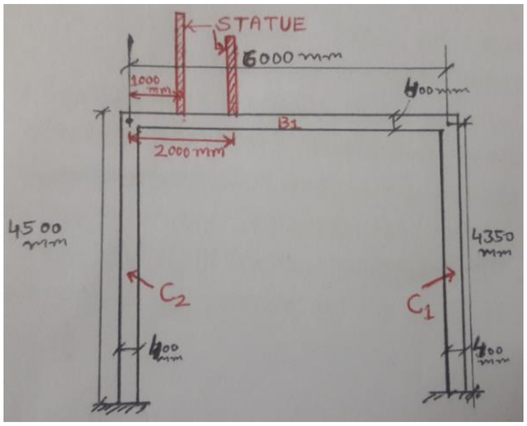
Design u.d.l. load (w_u) =1.5 * 16.19 = **24.285 Kn/m**

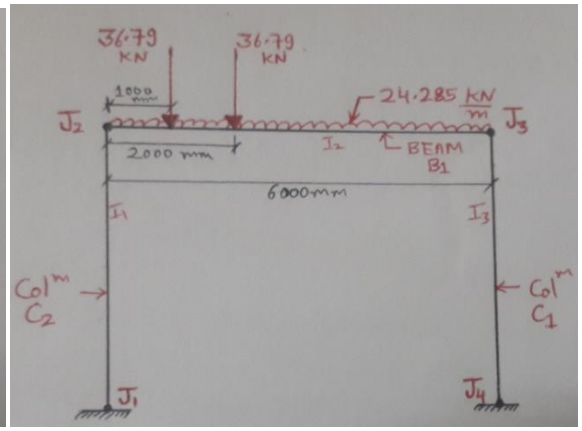
(iii) Self weight of statue fix at top of beam B_1

Q_1 = 2500kg =24525 N & Q_2 =2500kg = 24525N

Design concentrated load Q_{1u} & Q_{2u} each equal to 1.5* 24.525 Kn =**36.79 Kn**

4. ANALYZE BY MOMENT DISTRIBUTION METHOD





Data required:

Section of members C_1 to C_4 – 400mm * 400mm

Section of members B_1 and B_2 – 400mm * 400mm

Length of members C_1 to C_4 – 4350mm

Length of members B_1 and B_2 – 6000mm

Moment of inertia of members C_1 to C_4 – $I = 21.33 * 10^8 mm^4$

Moment of inertia of members B_1 to B_2 – $I = 21.33 * 10^8 mm^4$

JOINT	MEMBER	RELATIVE STIFFNESS	DISTRIBUTION FACTOR
J_2	J_2J_1	I/4.35	0.58
	J_2J_3	I/6	0.42
J_3	J_3J_2	I/6	0.42
	J_3J_4	I/4.35	0.58

Non Sway:

JOINT	**J_1**	**J_2**		**J_3**		**J_3**
MEMBER	**J_1J_2**	**J_2J_1**	**J_2J_3**	**J_3J_2**	**J_3J_4**	**J_4J_3**
D.F.		**0.58**	**0.42**	**0.42**	**0.58**	
C.O.	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**
F.E.M.			**-131.105**	**+94.315**		
Balancing		76.0409	55.0641	-39.6123	-54.7027	
C.O.	38.02045		-19.8062	27.53205		-27.3514
Balancing		11.48757	8.318583	-11.5635	-15.9686	

C.O.	5.743784		-5.78173	4.159292		-7.98429
Balancing		3.353404	2.428327	-1.7469	-2.41239	
C.O.	1.6767		-0.87345	1.2142		-1.2062
Balancing		0.5066	0.36685	-0.509964	-0.70424	
C.O.	0.2533		-0.25498	0.1834		-0.35212
Balancing		0.14789	0.10709	-0.077	-0.1064	
TOTAL	**+45.69** knm	**+91.54** knm	**-91.54** knm	**+73.89** knm	**-73.89** knm	**-36.89** knm

Horizontal reaction at J_1 , H_{J1} = $\frac{M_{J_1J_2}+M_{J_2J_1}}{4.35}$ = $\frac{+45.69+91.54}{4.35}$ = 31.547 Kn (→)

Horizontal reaction at J_2 , H_{J4} = $\frac{M_{J_3J_4}+M_{J_4J_3}}{4.35}$ = $\frac{-73.89-36.89}{4.35}$ = 25.467 Kn (←)

The value of **'P'** preventing side sway = 31.547 - 25.467 = **6.08 Kn (←)**

Side Sway:

Now let a **sway force S = 6.08 Kn (→)** be applied at J_2 .This will cause the columns J_1J_2 and J_3J_4 to rotate in clockwise direction and thus anti-clock moments will be induced at column heads such that

$$\frac{M_{J_2J_1}}{M_{J_3J_4}} = \frac{\frac{I}{L^2}}{\frac{I}{L^2}} = \frac{1}{1}$$

We shall assume arbitrary values of sway moments in the above proportion.

Let $M_{J_2J_1}$ = -1.0 Knm and $M_{J_3J_4}$ = -1.0 Knm

So, $M_{J_1J_2}$ is also -1.0 Knm and $M_{J_4J_3}$ is also -1.0 Knm

JOINT	**J₁**	**J₂**		**J₃**		**J₃**
MEMBER	**J_1J_2**	**J_2J_1**	**J_2J_3**	**J_3J_2**	**J_3J_4**	**J_4J_3**
D.F.		**0.58**	**0.42**	**0.42**	**0.58**	
C.O.	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**
F.E.M.	-1.0	-1.0			-1.0	-1.0
Balancing		+0.58	+0.42	+0.42	+0.58	
C.O.	+0.29		+0.21	+0.21		+0.29
Balancing		-0.1218	-0.0882	-0.0882	-0.1218	
C.O.	-0.0609		-0.0441	-0.0441		-0.0609
Balancing		+0.0256	+0.0185	+0.0185	+0.0256	
C.O.	+0.0128		+0.0093	+0.0093		+0.0128
Balancing		-0.0054	-0.0039	-0.0039	-.0054	
TOTAL	**-0.758** knm	**-0.522** knm	**+0.522** knm	**+0.522 k**nm	**-0.522** knm	**-0.758** knm

Horizontal reaction at J_1 , $H_{J1} = \frac{M_{J_1J_2}+M_{J_2J_1}}{4.35} = \frac{-0.758-0.522}{4.35} = 0.294$ Kn (←)

Horizontal reaction at J_2 , $H_{J4} = \frac{M_{J_3J_4}+M_{J_4J_3}}{4.35} = \frac{-0.758-0.522}{4.35} = 0.294$ Kn (←)

So for $\sum H = 0$, the sway force (S) = $H_{J1} + H_{J4}$ = 0.588 Kn (→)

When sway force (S) = 0.588 Kn (→) then moment induced are

JOINT	J_1	J_2		J_3		J_3
TOTAL	-0.758 knm	-0.522 knm	+0.522 knm	+0.522 knm	-0.522 knm	-0.758 knm

But magnitude of actual sway force is equal to P =**6.08 Kn.** So, moment induced are

JOINT	**J_1**	**J_2**		**J_3**		**J_3**
TOTAL	**-7.838** knm	**-5.4** knm	**+5.4**knm	**+5.4** knm	**-5.4** knm	**-7.838** knm

Moment in Non –Sway situation

JOINT	**J_1**	**J_2**		**J_3**		**J_3**
TOTAL	**+45.69** knm	**+91.54** knm	**-91.54** knm	**+73.89** knm	**-73.89** knm	**-36.89** knm

Final Moments

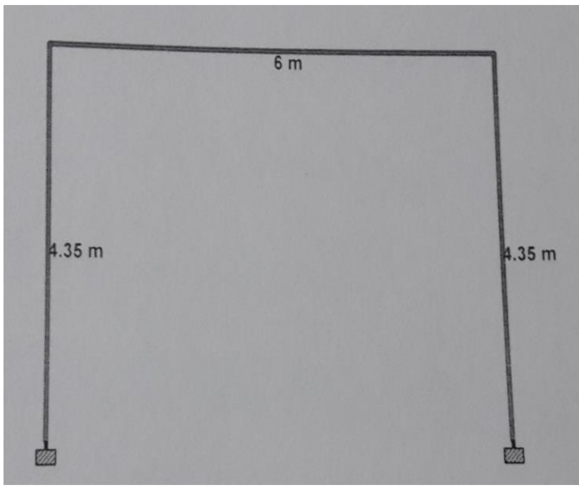
JOINT	**J_1**	**J_2**		**J_3**		**J_3**
TOTAL	**+37.85** knm	**+86.14** knm	**-86.14** knm	**+79.29** knm	**-79.29** knm	**-44.73** knm

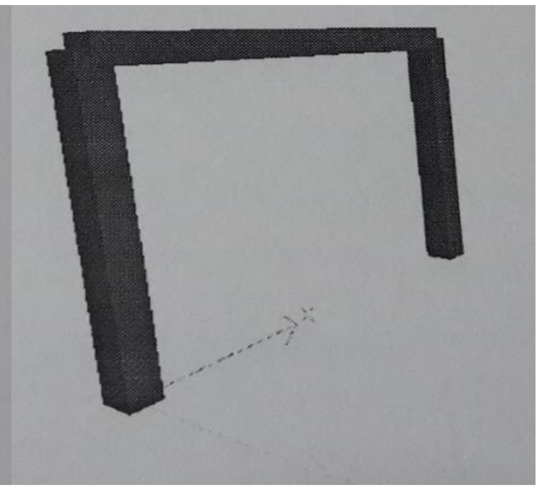
5. ANALYZE BY STAAD PRO SOFTWARE

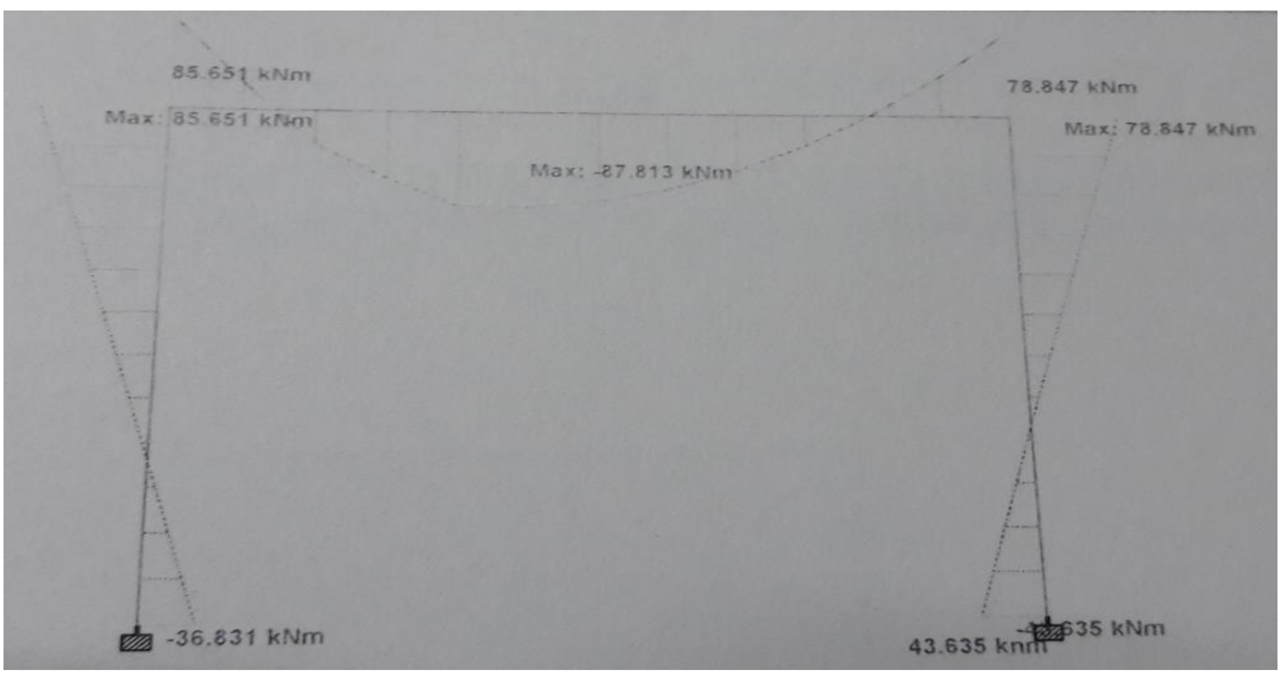
Input file:

```
JOINT COORDINATES
1 0 0 0; 2 0 4.35 0; 3 6 4.35 0; 4 6 0 0;
MEMBER INCIDENCES
1 1 2; 2 2 3; 3 3 4;
DEFINE MATERIAL START
ISOTROPIC CONCRETE
E 2.17185e+007
POISSON 0.17
DENSITY 23.5616
ALPHA 1e-005
DAMP 0.05
TYPE CONCRETE
STRENGTH FCU 27579
END DEFINE MATERIAL
MEMBER PROPERTY
1 TO 3 PRIS YD 0.4 ZD 0.4
CONSTANTS
MATERIAL CONCRETE ALL
```

SUPPORTS
1 4 FIXED
LOAD 1 LOADTYPE Dead TITLE DEAD
MEMBER LOAD
2 UNI GY -24.285
2 CON GY -36.79 1
2 CON GY -36.79 2
PERFORM ANALYSIS PRINT ALL
PERFORM ANALYSIS PRINT ALL
FINISH







6. CONCLUSION

By doing manual analysis, we got clarity on structural concept and gained more knowledge than analyze using software. Results obtained from Hardy Cross method and from STAAD – PRO software which is based on F.E.M. are same. We have felt the real engineering practice in this work.

7. ACKNOWLEDGEMENT

My sincere thanks to my department colleagues for their constraint help during my research.

REFERENCES

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[3] Structural analysis by Dr. R. Vaidyanathan.