COMPARISON OF EXPERIMENTAL AND FINITE ELEMENT MODEL RESULTS IN PREDICTING CONNECTION BEHAVIOUR – Top- & Seat- angle with Double web angle

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1. INTRODUCTION

Conventional analysis and design is usually carried out under the assumption that the connection between the beam and column is either fully rigid or ideally pinned. However, experimental observations have shown that most connections in practice possess intermediate stiffness, i.e. Semi-Rigid behaviour. Research has shown that the semi-rigid characteristic of a connection significantly influences the frame overall response e.g. distribution of internal forces and frame sway. With the availability of design guidelines on how to incorporate the semi-rigid behaviour into analysis of structures, one of the main factors now limiting the practical application of the concept of semi-rigid behaviour is the lack of a broad available database of connection behaviour.

2. METHODS OF PREDICTING CONNECTION BEHAVIOUR

Full scale and carefully conducted experimental test are regard as the most reliable method for predicting the actual connection behaviour in building frames, but due to the great variety of connections typologies and geometric properties, plus the expensive and time consuming undertaking required, has lead researchers to investigate other methods of predicting the connection behaviour. Existing methods for predicting the connection behaviour can be divided into five different categories[1], namely; Experimental testing, Finite Element models, Analytical models, Mechanical models and Empirical models

3. EXPERIMENT TEST AND FINITE ELEMENT MODEL SPECIMENS

In order to evaluate the reliability of generating connection behaviour data using Finite Element models, 15 no. Specimens were modeled (as per the available experimental data) and analyzed using a F.E. program, MARC. The MARC system, MARC and Mentat, contains an interactive computer program for processing data and a series of integrated programs that facilitate analysis of engineering problems. Similar to experimental specimens, each model depicted in Fig 1, had a pair of beam sections attached to a centrally positioned stub column. The pair of duplicated connection assemblies were made up of a top- and seat- angles bolted onto the column flange and beam flange, with double web angles bolted to beam web and column flange. The loading condition was by displacement control[2].

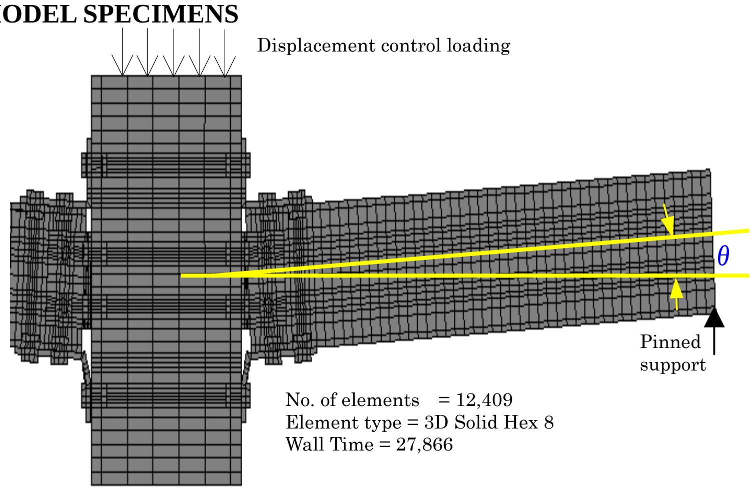

Fig 1. Symmetrical connection layout

4. ANALYSIS & COMPARISON OF RESULTS

F.E. model results were compared to Experimental results collected by Kishi and Chen in the Steel Connection Data SCDB data bank[3]. Points of interest, as illustrated in Fig 2, were the: - a) initial rotational stiffness K_i, b) flexural resistance moment (defined by Eurocode 3 as the curve value corresponding to secant stiffness equal to 1/3 initial stiffness[4]) M_{flxr}, and c) flexural resistance at 0.025Rad rotation $M_{0.025}$. The results are summarized in Table 1. The experimental and F.E. model generated moment-rotation curves for specimen 8S5 is plotted in Fig 2, clearly showing them in good agreement. The model can precisely analyze the connection elastic-plastic behaviour.

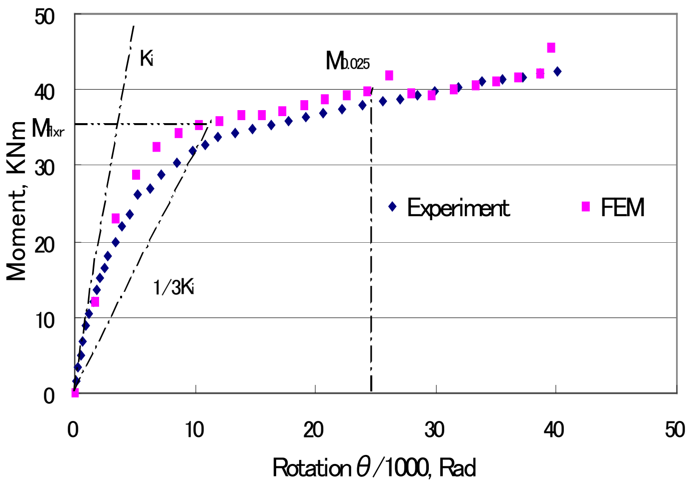

Fig 2. Moment-Rotation curve for specimen 8S5

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Table 1. Experiment and F.E. model stiffness and flexural resistance

								FEM RESULTS			EXP. RESULTS		
Specimen ID	Beam	Column	Top Flange angle thickness mm	Top Flange angle gage	Web angle thickness mm	Web angle length mm	Material Yield/Ultimate stress N/mm2	Initial stiffness KNm/rad	Flexuaral resistance KNm	Mmt resistance at 0.025rad,	Initial stiffness KNm/rad	Flexuaral resistance KNm	Mmt resistance at 0.025rad,
8S1	W8X21	W12X58	7.94	50.80	6.35	139.7	280/472	8,467	30.6	34.9	7,540	30.39	37.7
8S2	W8X21	W12X58	9.53	50.80	6.35	139.7	280/472	12,809	34.1	42.1	13,940	38.43	43.7
8S3	W8X21	W12X58	7.94	50.80	6.35	139.7	280/472	11,366	33.3	38.4	11,830	39.12	47.8
8S4	W8X21	W12X58	9.53	114.30	6.35	139.7	280/472	3,041	15.3	16.5	1,730	20.65	18.7
8S5	W8X21	W12X58	9.53	63.50	6.35	139.7	280/472	8,337	36.4	40.1	8,670	33.49	38.2
8S6	W8X21	W12X58	7.94	63.50	6.35	139.7	280/472	6,237	28.4	30.6	4,460	25.13	28.5
8S7	W8X21	W12X58	9.53	63.50	6.35	139.7	280/472	7,266	34.0	37.8	5,420	40.50	41.4
8S10	W8X21	W12X58	12.70	50.80	6.35	139.7	272/470	24,080	47.1	59.7	48,200	44.21	72.4
14S1	W14X38	W12X96	9.53	63.50	6.35	215.9	280/472	26,886	76.8	91.3	22,030	63.20	77.4
14S2	W14X38	W12X96	12.70	63.50	6.35	215.9	365/552	31,091	121.5	159.4	33,330	87.45	108.3
14S3	W14X38	W12X96	9.53	63.50	6.35	139.7	280/472	21,342	73.0	83.8	13,090	65.31	74.1
14S4	W14X38	W12X96	9.53	63.50	9.53	215.9	280/472	27,733	93.7	97.8	25,070	77.22	94.0
14S5	W14X38	W12X96	9.53	63.50	6.35	215.9	272/469	26,839	75.4	91.0	27,900	89.44	109.0
14S6	W14X38	W12X96	12.70	63.50	6.35	215.9	272/469	30,083	92.8	121.6	32,300	89.30	119.6
14S8	W14X38	W12X96	15.88	63.50	6.35	215.9	272/469	63,119	145.7	160.8	65,400	131.40	178.1

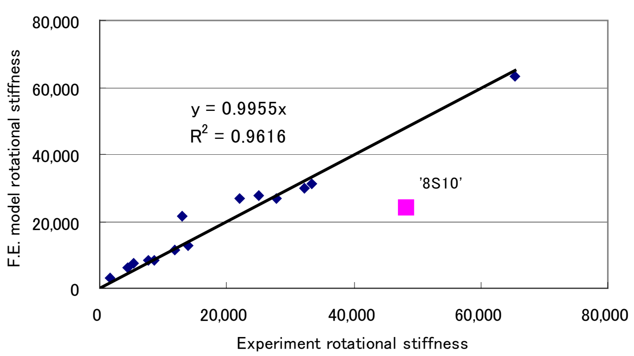

Fig 3. Comparison of Experimental and F.E. Model initial rotational stiffness results

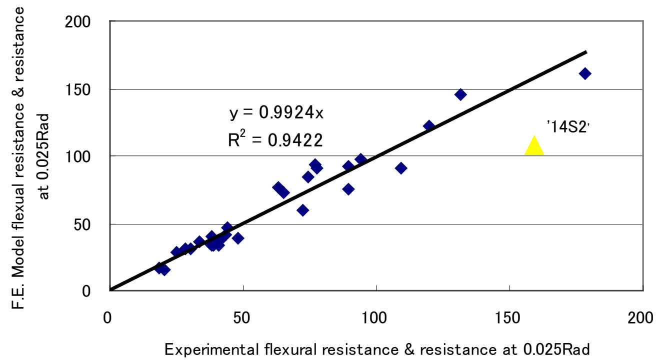

Fig 4. Comparison of Experimental and F.E. Model flexural resistance results

The following were observed: -

a) For all specimens, except specimen 8S10, F.E. models provide relatively close values for the initial connection rotational stiffness when compared to experimental results as shown in Fig 3.

b) According to Fig 4, besides specimen 14S2, F.E. model results for flexural resistance, M_{flxr} and resistance at 0.025 Rad, $M_{0.025}$ compared well to experimental results. Further, F.E. model results are logically more consistent than experimental results, for example experimental results indicate that 14S2 with a higher material strength and a thicker flange angle records a lower strength compared to 14S5.

c) Fig 5 shows that failure of specimens is due to yield line / plastic hinge formation in heel of angles and along the vicinity of bolt line on leg of angle bolted to column.

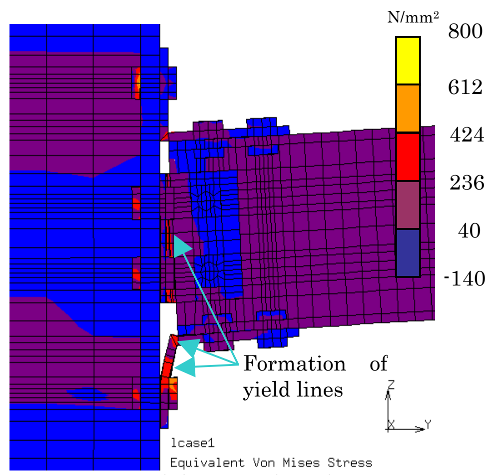

Fig 5. F.E. model stress distribution

5. CONCLUSION

Finite Element models can thus be used to generate and predict the full Moment-Rotation behaviour data of a connection that is compares well to experimental results. In order to input the connection behaviour data into structural analysis, the predicted behaviour will obviously be in the form of a mathematical representation.

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