I－A29 STRESS STRAIN RELATION AND CUMULATIVE DAMAGE DUE TO VARIOUS CYCLIC LOAD

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INTRODUCTION

During earthquake, critical part of structure experiences large and localised strain. Yet, we have not grasped well constitutive law of steel material in such high strain ranges.

In order to evaluate dynamic response and crack initiation of steel structural elements, cyclic stress-strain behaviour and low cycle fatigue of structural steels were studied.

TEST PROCEDURE

We employed SM490B steel as test material. Hourglass specimens were used to cope with large strain besides uniform gauge specimens. Table 1 summarised specimen and test conditions with brief results. The tests were carried out by controlling axial strain even for hourglass specimens with diametral extensometer. Four specimens with conspicuous characteristics are presented here among 18 specimens.

Loading pattern for No. 3 and 4 were got by strain gauges on steel pipes modelled bridge pier (H=1300 mm) during Hybrid test and cyclic loading test, respectively.

Table 1. List of specimens with test conditions

Specimen No.	Specimen Type	Loading Pattern	N_c	N_f
1	Uniform gauge	Constant Amplitude ε_a=4%, ε_m=0%	-	29
2	Hourglass	Constant Amplitude ε_a=7%, ε_m=0%	17	60
3	Hourglass	See Figure 1 (a)	20 blocks	33 blocks
4	Hourglass	See Figure 1 (b)	130	18 blocks

ε_a : strain amplitude, ε_m : mean strain, N_c : cycles to crack, N_f : cycles to failure

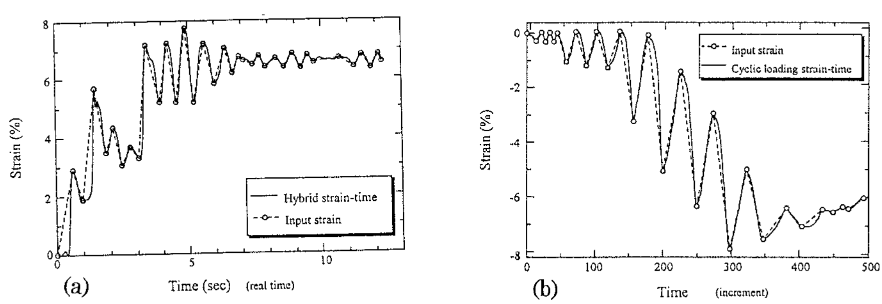

Figure 1 Loading Patterns for specimen No.3 and No.4

Key words : Stress-strain relation, low cycle fatigue, cumulative damage

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RESULTS AND DISCUSSIONS

Figure 2 shows stress strain curve for specimen No.1and No.2. They indicate typical hardening characteristic of mild steel. Yet, strangely, No.2 got longer fatigue life despite of higher strain amplitude.

On the other hand, stress-strain curve and its skeleton curve for specimen No.3 and No.4 are presented in Figure 3. No matter how strain changed, mean stresses were almost zero for both cases. Skeleton curves include only increasing parts of absolute value of stress. Specimen No.3 got almost coincident curves except for two lines, one was starting part of the test and the other was marked A in the figure. No.6 got different tendencies in tension and in compression. In tension stress area, curves were going down i.e. softening, as histories progressed. In compression stress area, lines traced on the elastic line (marked B) until it experienced whole yield plateau. After that lines made a bundle. In addition, both skeleton curves would not fit well especially in compression stress area as shown in Figure 4.

Since material got different stress-strain relation for different cyclic loading as shown till now, it is difficult and complicated to determine constitutive model for any cyclic loading. Not only loading pattern, but also other steels should be examined further.

Moreover, cumulative damage were calculated for specimen No.3 and No.4 according to Miner's rule, in which unity means fracture. Cumulative damage were 1.77 and 1.0, respectively. They give us risky assessment. We need another rule for evaluating safety under low cycle fatigue.

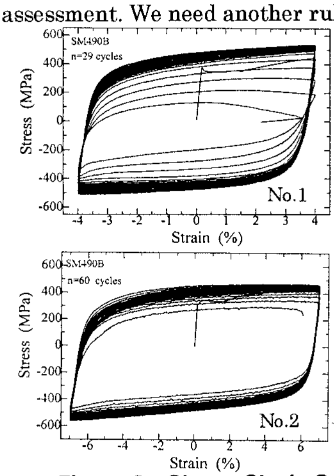

Figure 2 Stress-Strain Curves

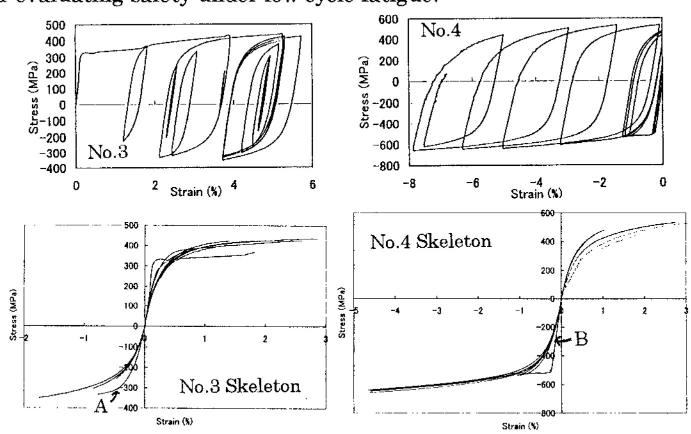

Figure 3 Stress-Strain Curves and Skeleton Curves

CONCLUSIONS

Stress-strain relation differs with cyclic loading patterns. Large strain induce made material lose its characteristic, hardening. Also, mean strain would have important rule to govern behaviour of materials.

In order to know behaviour of steel structures, we have to investigate much more about steel material itself.

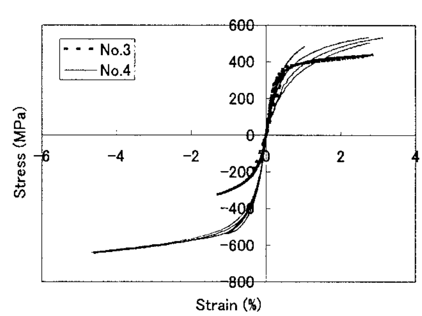

Figure 4 Comparison of Skeleton Curves

REFERENCE

1) Chitoshi MIKI, Jorge Müller and Tetsuya SASAKI, Study on Seismic Resistance of Steel Pipe Pier Made of Two Different Sections, JSCE No.605, pp.117-127, 1998.10