Simulation of cyclic plasticity behaviour of structural members

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Objekttyp: **Article**

Zeitschrift: **IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht**

Band (Jahr): **13 (1988)**

PDF erstellt am: **11.09.2024**

Persistenter Link: https://doi.org/10.5169/seals-13185

Simulation of Cyclic Plasticity Behaviour of Structural Members

Simulation du comportement de plasticité cyclique d'éléments de structures

Rechnerische Simulation des zyklisch-plastischen Verhaltens von Tragelementen

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1.INTRODUCTION

Computer simulation of the cyclic plasticity behaviours of structures or structural members is very important to evaluate structural safety and make them safe against severe cyclic loading due to earthquakes, wind storms and so on. Here a cyclic plasticity theory for elasto-plastic hysteretic behaviours of structural steel is proposed and it is applied to the analyses of structural members subjected to cyclic loads.

2.CYCLIC PLASTICITY MODEL

The proposed model is derived by the refinements of a multi surface plasticity theory introduced by Petersson and Popov[1]. Petersson-Popov model used cumulative equivalent plastic strain as a state variable, two fundamental surface size functions and a weighting function as material property functions.

There are three important differences between Petersson-Popov model and the proposed model. Firstly, effective value of cumulative equivalent plastic strain is defined as a state variable to represent "Return Phenomena". Secondly, additional material property functions are introduced. These functions express strain hardening characteristics of materials after loading histories corresponding to certain values of cumulative equivalent plastic strain. Owing to this modification, the theory can express strain hardening characteristics of materials with both notable strain hardening and non-hardening strain region. Thirdly, all of the material property functions can easily and unambiguously be obtained by a combination of a simple tension test and several simple tension-compression tests.

3.APPLICATION OF THE MODEL

This method is applied to simulation of tension-compression stress-strain relationships of mild steel and high strength steel. Using material property functions measured, the authors carried out elasto-plastic finite element analyses for round-bar specimens subjected to repetitive tension-compression loading under controlled strain. Figure 1 shows stress-strain relationships predicted by the proposed model and those gained by the corresponding experiments. By comparing these results, it was confirmed that the stress-strain relationships calculated by the proposed theory was accurate.

A next application of the cyclic plasticity model is the evaluation of bending moment-curvature relationships(M-Φ relationships) of steel beams. In the calculation of the M-Φ relationships of beams and beam-columns by the proposed

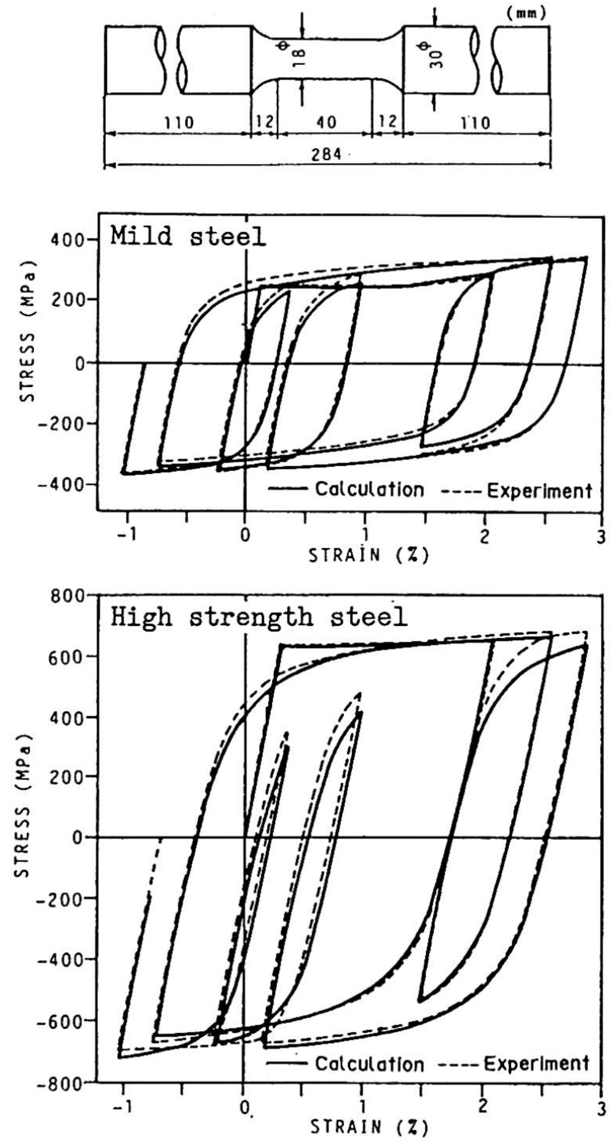

Figure 1 Stress-strain relationships of round bar specimens.

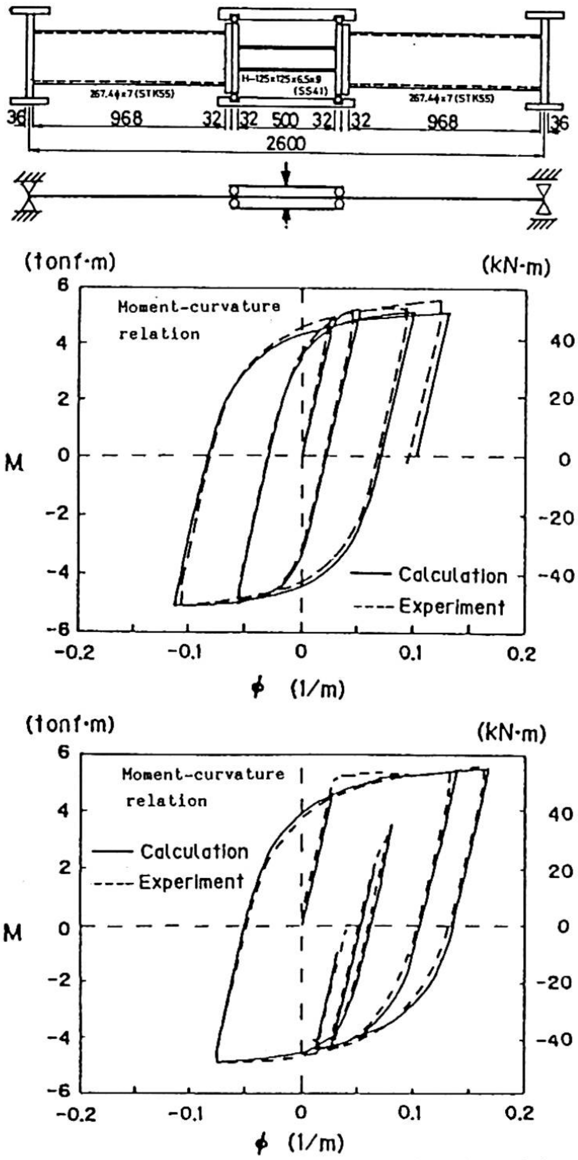

Figure 2 Moment-curvature relationships of simple beam specimens.

stress-strain model, the tangent stiffness method introduced by Chen and Atsuta[2] was used with some modifications.

JIS(Japanese Industrial Standards)-5 type specimens were shaped from a H-shaped beam specimen to evaluate material property functions. Material property functions were determined by a combination of tension tests and tension-compression tests. Residual stress characteristics were analyzed by a drilling method and simple type distribution was assumed according to these results.

The calculated M-Φ relationships are compared with those obtained by experiments which the authors had carried out. Figure 2 shows hysteretic M-Φ relationships predicted and those gained by the corresponding experiments. The accurate M-Φ relationships can be evaluated by the authors' theory.

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