Identification of Hysteretic Systems with Slip

Shujin Li  Yoshiyuki Suzuki

1 Introduction
Hysteretic models with slip are frequently used to predict the non-linear behavior of wood structural systems. Such models are typically characterized by control parameters that have to be identified from observed experimental testing. A smoothed hysteretic slip model, which can describe the pinching of hysteresis loops perfectly was proposed by Baber and Noori based on the Bouc-Wen model[1]. The model, called SL model, consists of a nonpinching hysteretic element in series with a ‘slip-lock’ element. Here the parameters identification of this model is to be considered.

2 Hysteretic Model
The differential system model proposed by Baber and Noori[1] to describe hysteretical system with slip is

\[ \ddot{x} + ax + bx + z = f(t) \quad (1) \]
\[ \dot{z} = A\dot{x} - \beta |\dot{x}| \dot{z}^{n-1} - \gamma |\dot{x}|^{n} \quad (2) \]
\[ \dot{x}_2 = \sqrt{\frac{2}{\pi}} \frac{s}{\sigma} \exp \left[ -\frac{z^2}{2\sigma^2} \right] \dot{z} \quad (3) \]
\[ x = x_1 + x_2 \quad (4) \]

In general the magnitude of slip \( s \) may be varied with the history of response. In this model \( s \) is supposed as a function of the system energy dissipation \( E(t) \) as follows
\[ s = \delta \dot{E}(t) \quad (5) \]

Here the hysteresis loop pinching is added by incorporating a time-dependent ‘slip-lock’ element as shown in Figs. 1.

Fig. 1 Slip-lock series hysteresis

A detailed explanation of the physical meaning of the model parameters is available [1]. The parameters need to be identified are \( a, b, A, \beta, \gamma, n, \delta, \) and \( \sigma \) for this model.

3 Parameter Identification
A method of estimating the parameters of such a model on the basis of input-output data is suggested, which is based upon Gauss-Newton iterations. A three-stage iterative procedure is proposed in order to reduce the crucial and complicated of the convergence due to the large dimension of parameters of this problem. And analytical simulation studies of this algorithm to a SDOF hysteretic system with slip are performed.

References