ABOUT STABILITY LOSS DURING DISPLACEMENT-CONTROLLED LOADING

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Abstract

The paper presented deals with a stability loss during displacement-controlled loading, which is possible due to the low rigidity of the loading set up. This stability loss appears as a jump in measured parameters. A procedure was developed for recognition of this problem and its correction in the case of fracture tests on specimens of concrete. This procedure is used here to mention that trouble.

Keywords: Stability loss; catastrophe; fold singularity; displacement-controlled loading; load–deflection diagram.

1 Introduction

A quasi-static loading is typically used to measure of values of building materials properties. A very slow change of load or displacement is considered in case of this loading. Fracture tests – e.g. in configuration of three-point bending (3PB) of notched specimens – are focused on the quantity of energy which is dissipated by collapse of a specimen. Mentioned displacement-controlled loading is used for quantification of this fracture energy [7, 8, 9, 10]. Typical load–deflection diagram from 3PB test is possible to see in Figs. 1 and Fig. 2.

The response of a specimen is suggested by the stiffness of the loading machine and by the stiffness of intermediate parts of the specimen. A qualitative change in the measured loading diagram can appear during low stiffness of the loading machine. This change can be observed as a sudden loss of loading stability. This stability loss is caused by achieving of the so-called 'fold catastrophe' with regard to catastrophe theory [1, 2]. 'Catastrophe' in this theory means the occurrence of a sudden change in the inner parameter of a system during continuous change of a control parameter.

Results of fracture test measurements show, that analysis of a measured time series of inner system parameters can serve for recognition of catastrophe origination. During a typical time series of loading point displacement there can be visible irregularity in loading speed and first of all a sudden increase in displacement – see Fig. 2. Therefore, the time derivative of this displacement is a useful criterion of the origination and range of the

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fold catastrophe. The catastrophe is recognizable as extreme values of loading speed (Fig. 3). The corrected loading diagram and fold catastrophe have such properties which can help discover the probable development of the diagram in the catastrophic part. As a first attempt to create an algorithmic development of this correction a third order polynomial was applied here (Fig. 4).

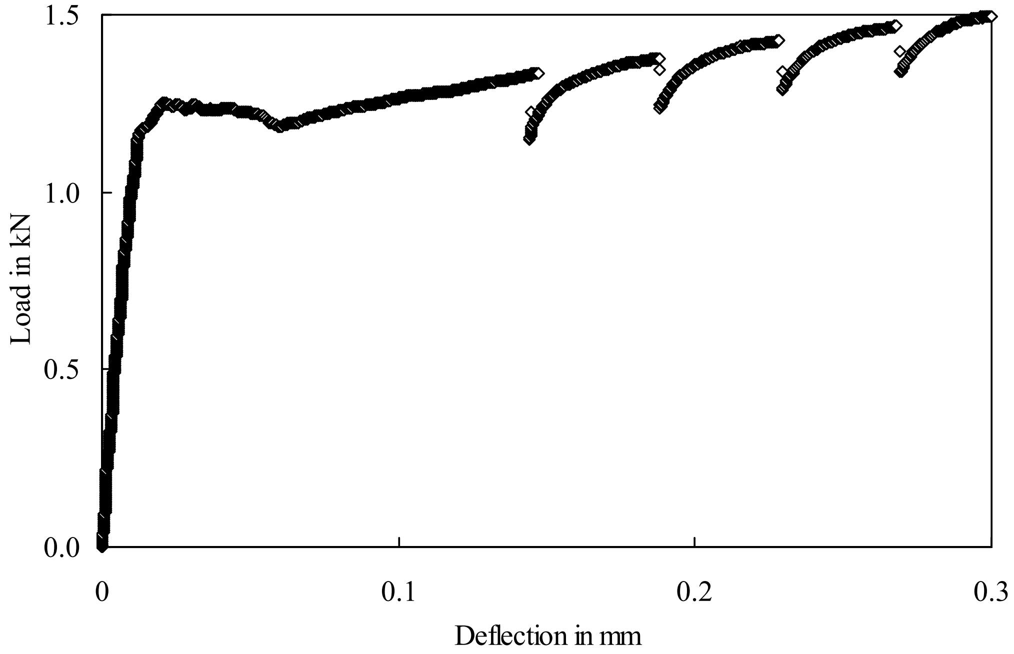


Fig. 1 Detail of selected load–deflection diagram: 3PB of fibre concrete specimen

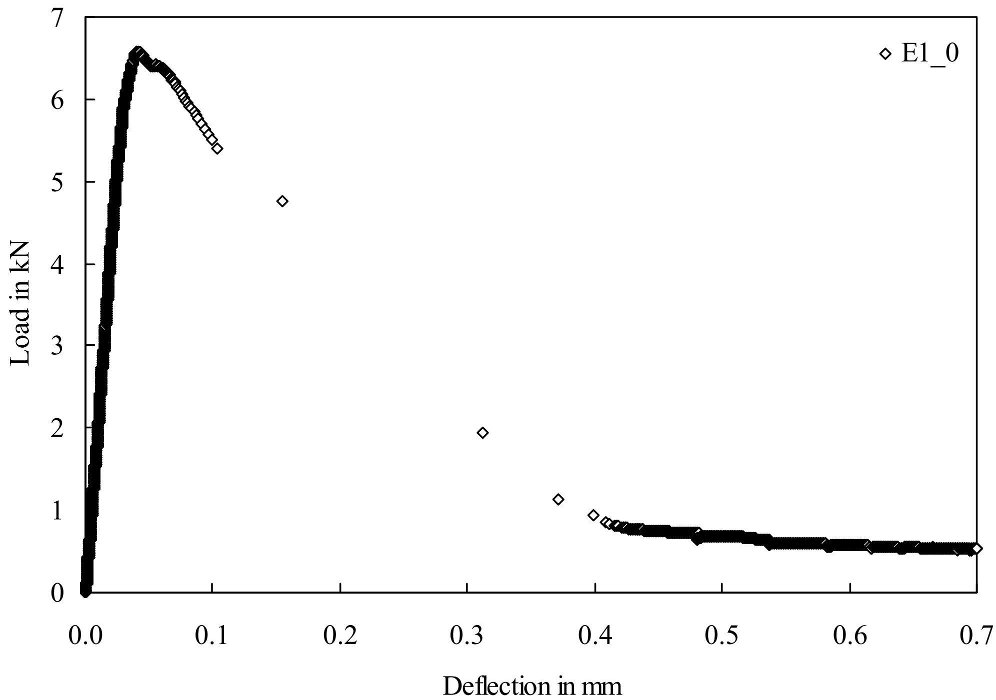


Fig. 2 Selected load–deflection diagram (E1) before correction: 3PB of plain concrete specimen

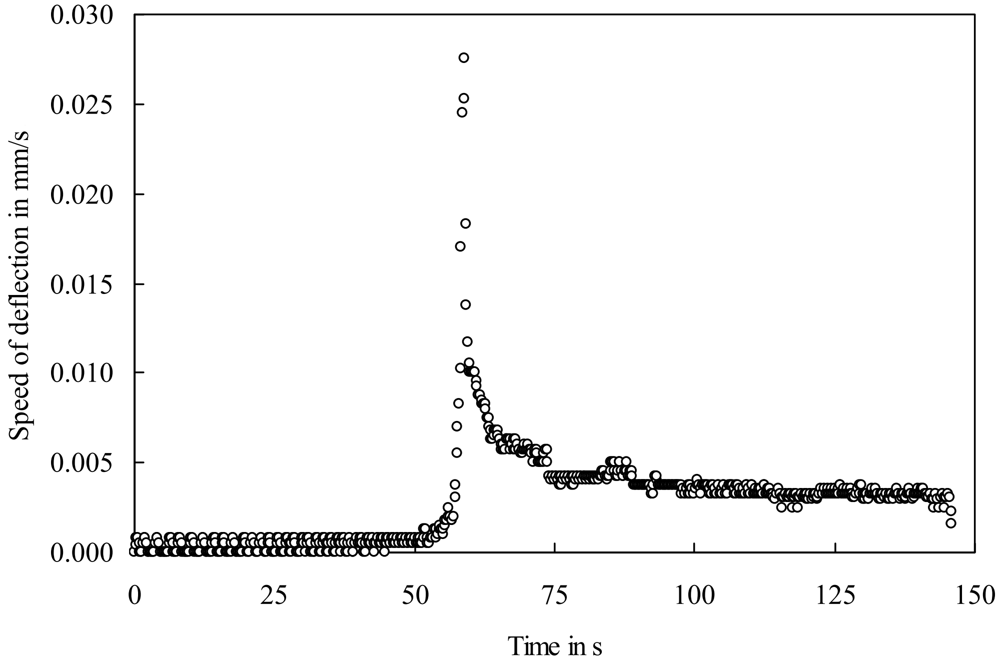
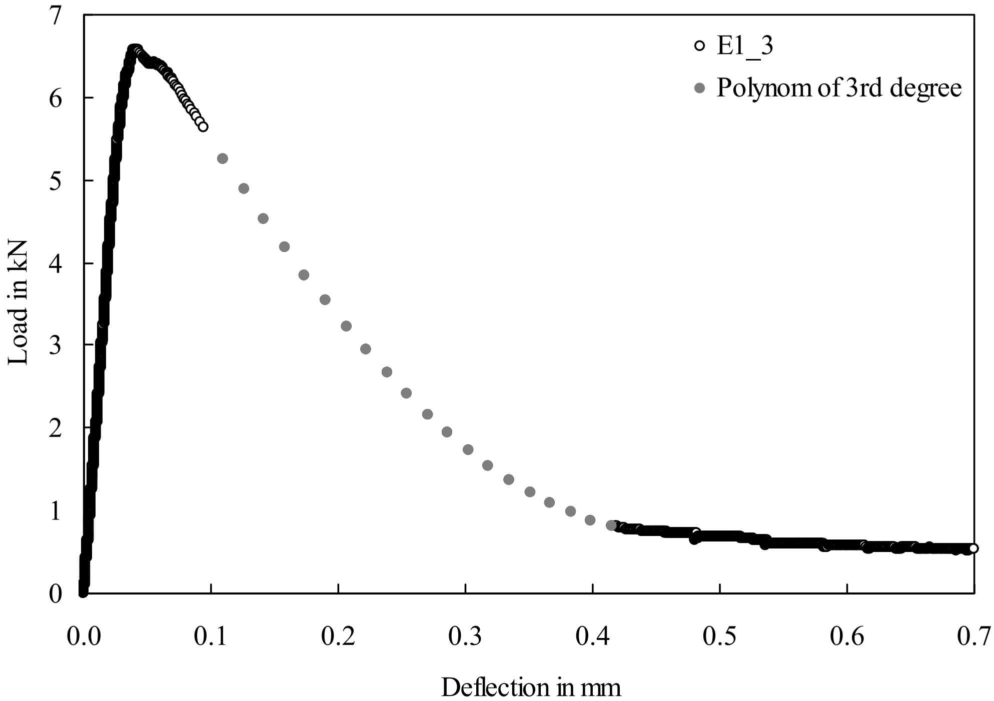


Fig. 3 Time derivative of measured time series of deflection (E1)



Tab. 4 Load–deflection diagram (E1) after correction

2 Conclusions

The individual steps in the procedure were applied:

- calculation of the time derivative of the tested specimen's displacement,
- recognition of the catastrophe and deletion of the irregular points,
- determination of the approximation parameters,
- finding an approximation, and
- addition of new points with regard to found approximation.

Note the values of work of fracture and specific fracture energy from the measured load–deflection diagram without correction can be overestimated. See details e.g. in [3, 4, 5, 6].

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