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Possibility of Application of the Simulation Based Assessment Method in Modelling of Structures

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Abstract. The article deals with possibility of application of the simulation based reliability assessment SBRA Method in modeling of structures in the field of judgement of their serviceability. A steel supported beam of rectangular cross sectional area was taken into account. Strains of the model were determined using electrical resistance straingange method were determined. Because of the same material of the model and real beam, strains and stresses are the same in both cases.

At the first step a model of the beam was created and necessary corresponding station modulus was determined for real beam using modeling rules.

It means that inverse procedure was used in that case. Stresses of the model and corresponding beam were determined using SBRA when fallowing random variable quantities as section modulus of the beams, Young´s modulus of elasticity E and evading force were taken into account.

Introduction

The article deals with an ability to assess the reliability of structural element on its model by means of the simulation based reliability assessment SBRA Method. The aim is to present a possibility of judgement of probability of failure of real component on its model. Steel beam (Fig. 2) was taken into account as a model of real steel beam. Stresses of steel beam and its model were determined using SBRA Method too. Obtained results were compared.

The simulation Based Reliability Assessment Method is a probabilistic method using the Monte Carlo simulation [1, 3]. Probability of failures of model and real beam were determined using Anthill software [3].

Modelling of engineering problems can be a way to solve them. This method is generally based on the conditions

$$(\pi_i)_S = (\pi_i)_M, \quad i = 1, 2, \ldots, m \tag{1}$$

where π_i are so called dimensionless parameters for structure (subscript S) and model (subscript M). Probability of failure is guided by so called safety function.

$P_{f(i)} = R_{(i)} - S_{(i)}$ (2)

Where **S** is the load effect And **R** is the structural resistance. The probability of failure P_f of a body can be then expressed as a ratio between the number N_f of results that do not fulfil the defined before by safety function Eq.3 and the total number of results of safety function N_t [1], see Fig. 1. Then

$P_f = N_f / N_t$ (3)

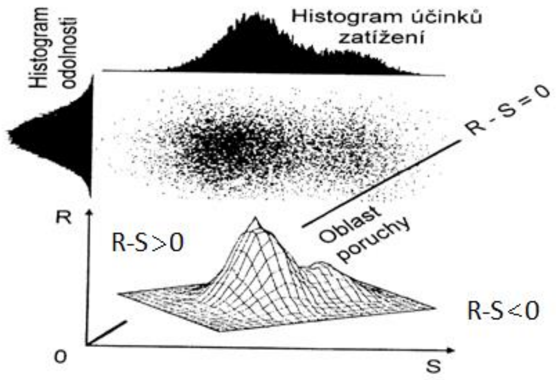

Fig. 1 Probability of failure

Experimental results

The used steel model in mm is stated in Fig.2. Loading forces were F=100, 200, 300, 400, 450 N. Strains were measured using electrical-resistance gages. Fig. 1. Recorded values of strains and corresponding stresses are in the Tab. 1. To determine corresponding state in real steel beam length of l=2500 mm rules of modelling were used and loading forces F_B and section

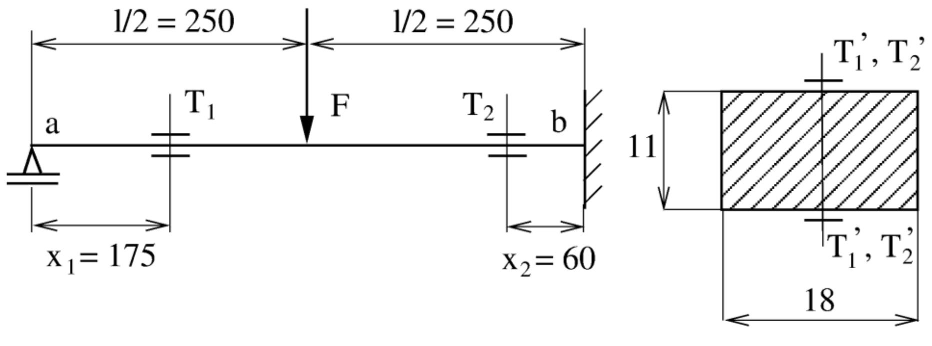

Fig. 2 Model of the beam

modulus W_B were determined. Material of model and of real beam was the same therefore stresses in the model and in the real beam are the same, steel S235 with Young´s modulus of elasticity E =2.1x10^5 MPa was used, see the Tab. 1.

Tab.1 Results of the model and of the beam

Model experiment	**F_m[N]**	**300**	**450**
	$2\ \varepsilon_{1m}\,x10^{-3}$	0.225	0.33
	σ_{1m} [Mpa]	47.25	69.30
	$2\ \varepsilon_{2m}x10^{-3}$	-0.165	-0.26
	σ_{2m} [Mpa]	-34.65	-54.6
Beam	**F_B**[kN]	7.5	11.25

Results of model and SBRA simulation is obvious in Tab. 2.

Tab.2 Results of model and of SBRA simulation

F_m[N]	**300**			**450**		
F_B[kN]	**7.5**			**11.25**		
	MODEL exp.	**SBRA-m**	**SBRA-B**	**MODEL exp.**	**SBRA-m**	**SBRA-B**
$2\varepsilon_{1m}\,x10^{-3}$	0.225	-	-	0.33	-	-
$2\varepsilon_{2m}\,x10^{-3}$	- 0.165	-	-	-0.26.	-	-
σ_1 [MPa]	47.25	45.190	45.202	69.30	67.79	67.80
σ_2 [MPa]	-34.7	-34.29	-34.19	-54.60	-54.48	-54.32
$\sigma_{1Det.}$[MPa]	45.2			67.79		

m - **Model,** B – **Beam,** Det. – **beam determined**

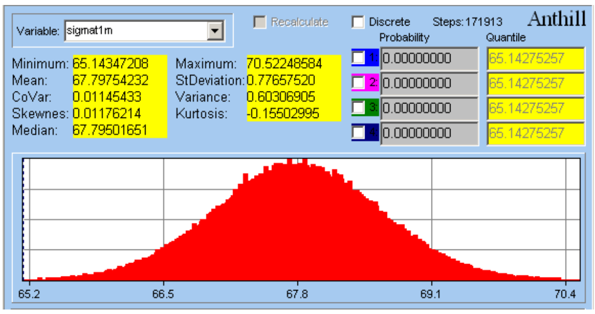

Fig.3 The resulting stress σ_{1m} [MPa]

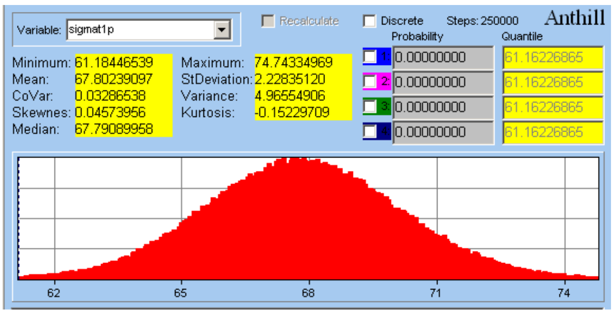

Fig.4 The resulting stress σ_{1B} [MPa]

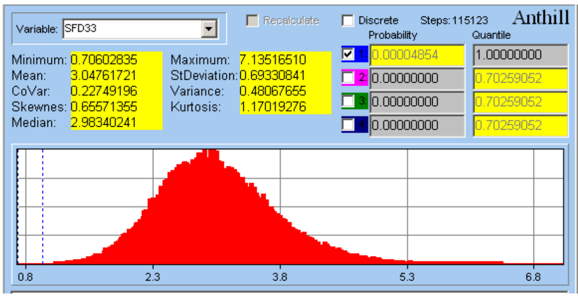

Fig.5 Probability of failure Pf(i), SF(i)

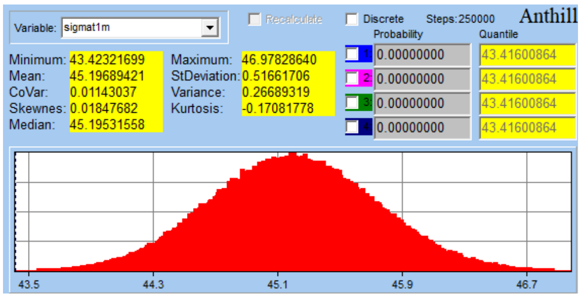

Fig.6 The resulting stress σ_{1m} [MPa]

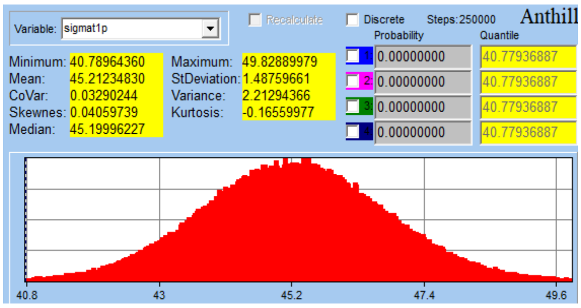

Fig.7 The resulting stress σ_{1B} [MPa]

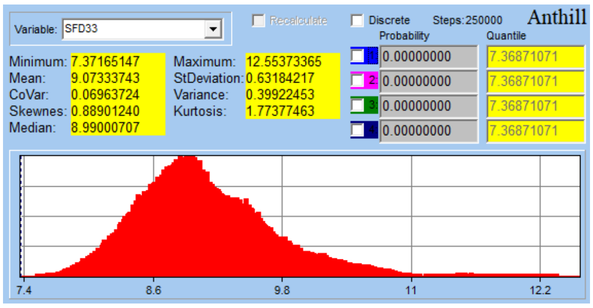

Fig.8 Probability of failure Pf(i), SF(i)

In Fig.3. and Fig.4. there are for illustration presented histograms of the resultant stresses and section modulus and in Fig. 5. is presented histogram of probability of failure all for the loading of F_m= 300 N and figures 6. ,7. and 8. for the load F_m= 450 N.

Probability of failures of the beam determined using SBRA method were $\mathbf{P}_{f(i)B} = 4{,}8 \cdot 10^{-5}$ and for the model $\mathbf{P}_{f(i)m} = 4{,}103 \cdot 10^{-5}$.

Obtained results show very good correspondence. It gives a sure possibility for determination of failure probability of structure to determine it using corresponding model.

Acknowledgements

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References

[1] Pláníčka, F., Šolc, M., Marek, P.: From Partial Factors Design to the SBRA Probabilitistic Method, Acta Mechanica Slovaca Vol.15, No 2, 2011, ISSN 1335-2393, pp. 22-27.

[2] Pláníčka, F., Krystek, J.: Dimensional Analysis and Modelling in Mechanics of Materials, Proceedings of 28th Danubia-Adria Symposium on Advances in Experimental Mechanics 2011, Siófok, Hungary, ISBN 978-963-9058-32-3, pp. 229-230.

[3] www.sbra-anthill.com/lit/publications.