Projekt je sufinancirala Europska unija iz Europskog fonda za regionalni razvoj. Ulaganje u budućnost!

Title: **Dynamic Fracture of Materials and Structures**

The behavior of materials and structures is strongly influenced by the loading rate. Compared to quasi-static loading structures loaded by impact loading acts in a different way. First, there is a strain-rate influence on strength, stiffness and ductility and, second, there are inertia effects activated, due to different reasons, which influence the resistance and failure mode.

Recently, an explicit finite element code has been developed for the simulation of high velocity impact and fragmentation events. In the code the rate sensitive thermo-mechanical microplane constitutive law for brittle (e.g. glass), quasi-brittle (e.g. concrete) and ductile (e.g. steel) materials is used. The model is extended to account for large deformations. Failed elements on the way are removed with the technique based on element deletion. Large deformation frictional contact has been treated by forward incremental Lagrange multiplier method. In order to investigate the role of rate sensitive constitutive law and inertia effects, different problems were studied in the past. The comparison between experimental and numerical results showed that the model is able to correctly simulate phenomena related to high strain rates and impact, such as rate dependent structural resistance and failure mode, prediction of crack velocity and crack branching.

In the presentation results of a series of numerical simulations for different materials and structures are presented and discussed. Studied are brittle, quasi-brittle and ductile materials. The influence of loading rate for brittle and quasi-brittle materials is investigated on compact tension (CT) specimen, modified Hopkinson bar and on projectile perforation of plain concrete slab. Dynamic fracture of ductile material (steel) is studied on CT specimen. The results of numerical investigation are compared with the own experimental results and with the results from the literature. It is shown that the progressive increase of resistance (apparent strength or toughness), which is observed in experiments, for almost all materials, cannot be attributed to the increase of the material strength. It is due to the inertia effects and is closely related to the phenomena of crack branching and damage. Therefore the progressive increase should not be a part of the constitutive law, i.e. it should come automatically out as a result of dynamic analysis. In brittle materials this effect is much less pronounced than in quasi-brittle (concrete) and ductile materials (steel). It is observed that maximum crack velocity, at which crack branching initiates, is not much different for ductile and quasi-brittle materials, i.e. it is in the range of approximately 500 m/s (steel) to 700 m/s (concrete). It is concluded that rate sensitivity of quasi-brittle materials (e.g. concrete) is relatively strong and cannot be neglected, for instance in impact events. Finally, in case of ductile materials the size of the plastic and localization zone strongly depends on strain rate, i.e. increase in strain rate cause decrease of both. This implies that the brittleness of ductile materials increases with increase of strain rate.

Ministarstvo znanosti, obrazovanja i sporta

Ministarstvo znanosti, obrazovanja i sporta
Donje Svetice 38
10000 Zagreb
tel: +385 1 4594-325
fax: + 385 1 4594-349
www.mzos.hr

Sveučilište u Zagrebu Fakultet strojarstva i brodogradnje
Ivana Lučića 5
HR-10000 Zagreb
tel: + 385 1 6168 450
fax: + 385 1 6168 187
www.fsb.unizg.hr

CEEStructHealth

Centar izvrsnosti za procjenu stanja konstrukcija
Voditelj projekta: prof. dr. sc. Zdenko Tonković
tel: + 385 1 6168 450; fax: + 385 1 6168 187
email: **info@ceestructhealth.eu**
www.ceestructhealth.eu

Središnja agencija za financiranje i ugovaranje
Vukovarska 284 (objekt C9),
10000 Zagreb
tel: +385 1 459 1245
fax: +385 1 459 1075
www.safu.hr

Fond za ulaganje u znanost i inovacije
Donje Svetice 38
10000 Zagreb, Croatia
tel: + 385 1 4594 434
www.siif-croatia.com