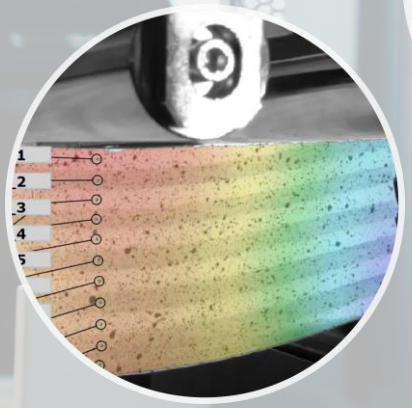
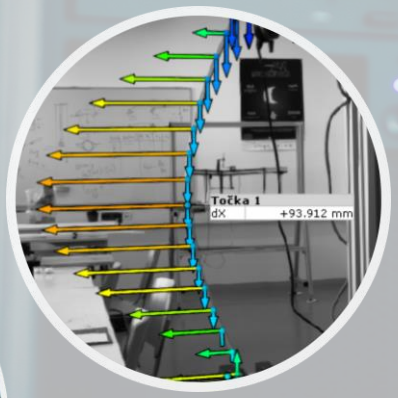
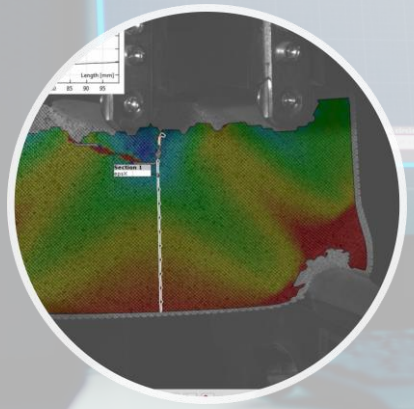
PROGRAM **MIKROKVALIFIKACIJE:**

PRIMIJENJENA MEHANIKA U SUVREMENOJ INŽENJERSKOJ PRAKSI







Sveučilište u Rijeci
Građevinski fakultet

PROGRAM **MIKROKVALIFIKACIJE:**

PRIMIJENJENA MEHANIKA U SUVREMENOJ INŽENJERSKOJ PRAKSI

diplomski studij
Građevinarstvo
smjer **Konstrukcije**

4 izborna predmeta
u 2. semestru

može se upisati kao
program cjeloživotnog učenja
(dostupan onima koji nisu studenti)

može se slušati na
engleskom jeziku
(preporučljivo)

stjecanje
znanja, vještina i kompetencija
+
nove mogućnosti zapošljavanja

izdavanje
potvrde o završenom programu

G F
Sveučilište u Rijeci
Građevinski fakultet

Diplomski sveučilišni studij GRAĐEVINARSTVO

Smjer: **KONSTRUKCIJE**

I. Semestar

II. Semestar

III. Semestar

IV. Semestar

Obavezni predmeti

- Čelične konstrukcije
- Drvene konstukcije
- Dinamika konstrukcija

Izborni predmeti

PRIMIJENJENA MEHANIKA
U SUVREMENOJ INŽENJERSKOJ PRAKSI

- Stabilnost konstrukcija
- Plošni nosači
- Energetske metode u primijenjenoj mehanici
- Uvod u modeliranje plastičnosti i oštećenja


[1]

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[5]

[6]

[7]

ECTS bodovi

Stabilnost konstrukcija	4
Plošni nosači	3
Energetske metode u primijenjenoj mehanici	3
Uvod u modeliranje plastičnosti i oštećenja	4
PRIMIJENJENA MEHANIKA U SUVREMENOJ INŽENJERSKOJ PRAKSI	14
+	
Obavezni predmeti	16
II. Semestar ukupno:	30


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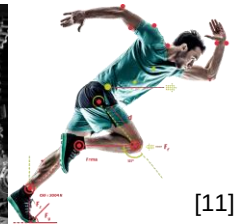
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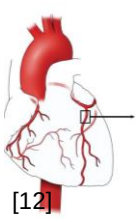
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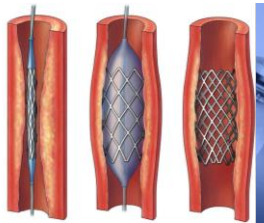

[13]

izv. prof. **Dragan Ribarić**
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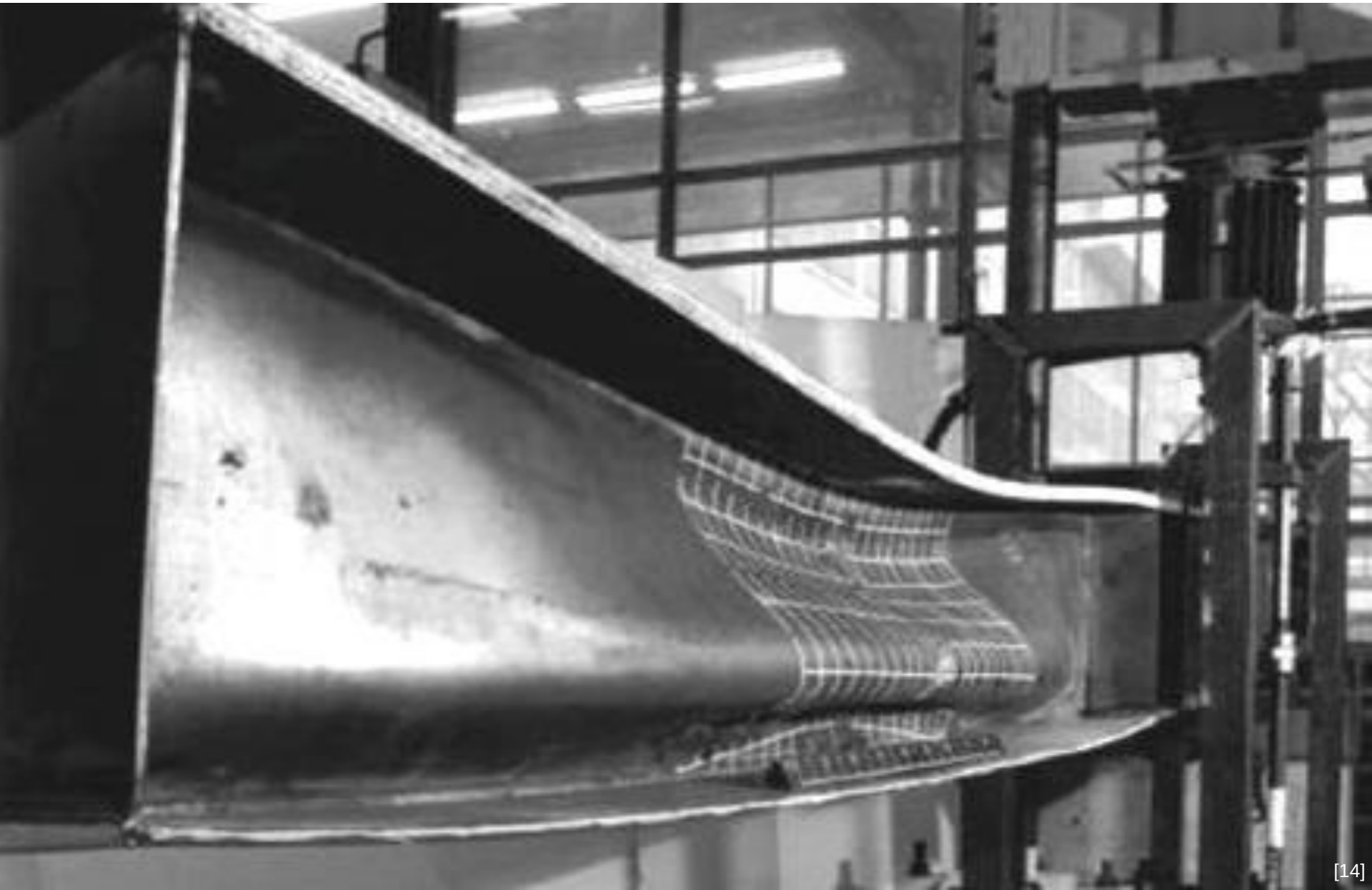
Stabilnost konstrukcija



Stabilnost konstrukcija

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Postoji praktična potreba za analizom sigurnosti po pitanju nestabilnosti izazvanih kombinacijom geometrije konstrukcije i unutarnjih sila.
U tu svrhu razvila se nova disciplina – **stabilnost konstrukcija**.

Stabilnost konstrukcija

Teorija

Problem geometrijske nestabilnosti izražen je pomoću unificiranih diferencijalnih jednadžbi koje su rezultat kombinacije kinematičkih i materijalnih izraza, te jednadžbi ravnoteže.

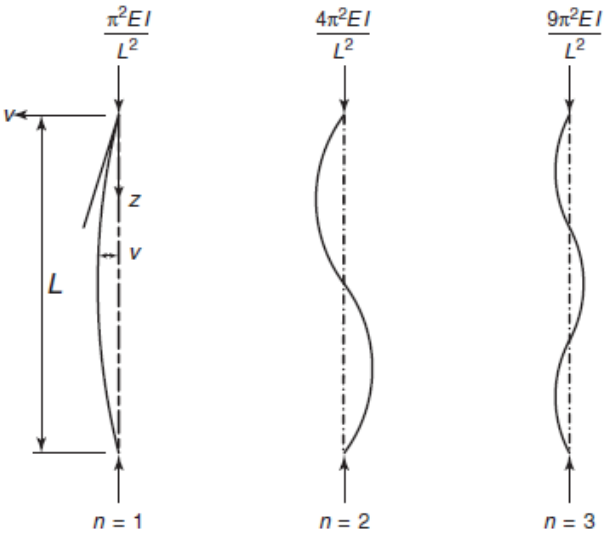
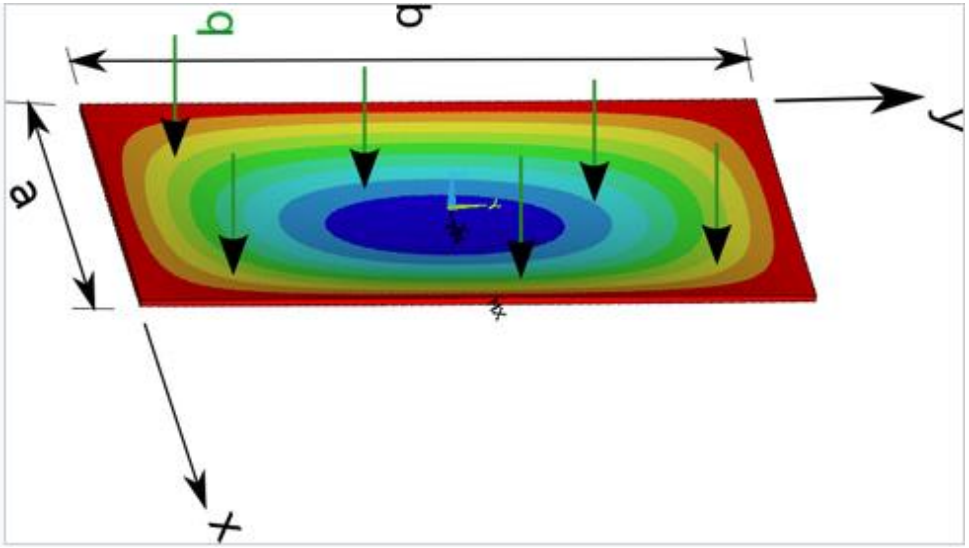


Fig. 2.5 Mode shapes of buckled column. [19]

$$\frac{d^4 w}{dx^4} + \frac{P}{EI}\frac{d^2 w}{dx^2} = \frac{q}{EI}$$



[18]

$$\frac{\partial^4 w}{\partial x^4} + 2\frac{\partial^4 w}{\partial x^2 \partial y^2} + \frac{\partial^4 w}{\partial y^4} + \left(\frac{n_x}{D}\frac{\partial^2 w}{\partial x^2} + 2\frac{\tau_x}{D}\frac{\partial^2 w}{\partial x \cdot \partial y} + \frac{n_y}{D}\frac{d^2 w}{dy^2}\right) = \frac{q}{D}$$

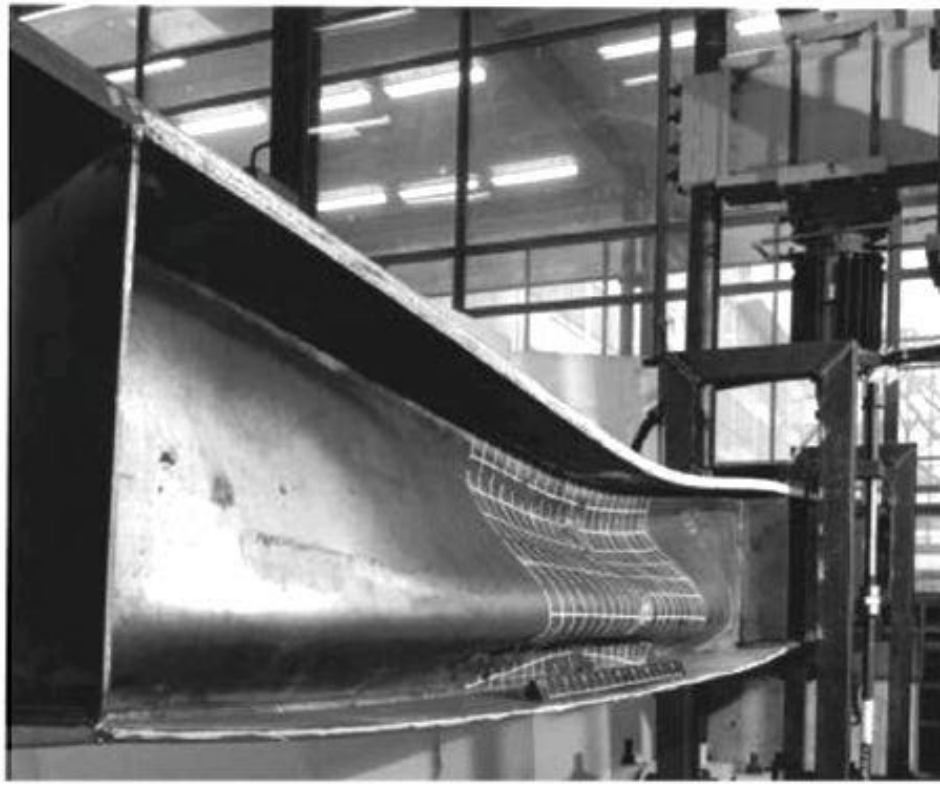
Leonhard Euler
(1707 – 1783)
mathematician

[20]

Stabilnost konstrukcija

Eksperimenti

Eksperimentalna postavka modelira praktični problem i potvrđuje teorijske rezultate.



[14]

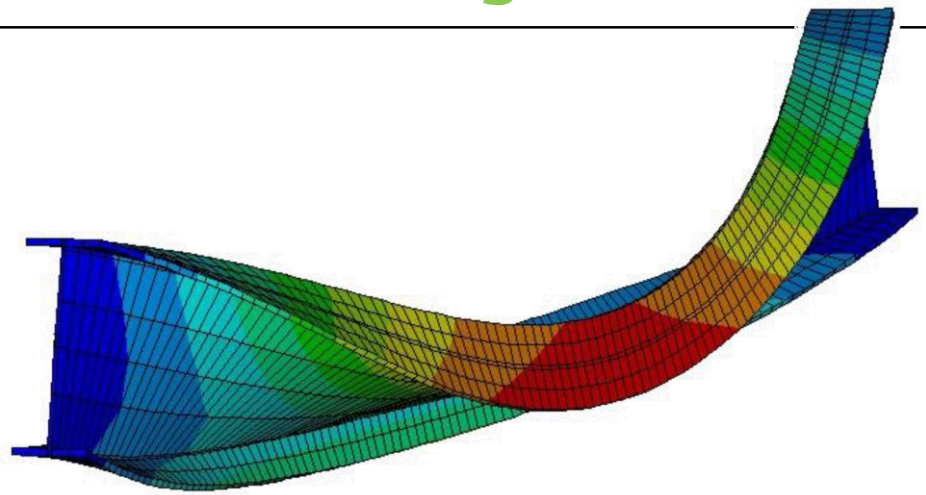
Figure 2. Vertical web buckling.

[21]

Stabilnost konstrukcija

Numerička rješenja

Numeričkim metodama mogu se riješiti kompleksni praktični problemi.
Najčešće korištena je Metoda konačnih elemenata.



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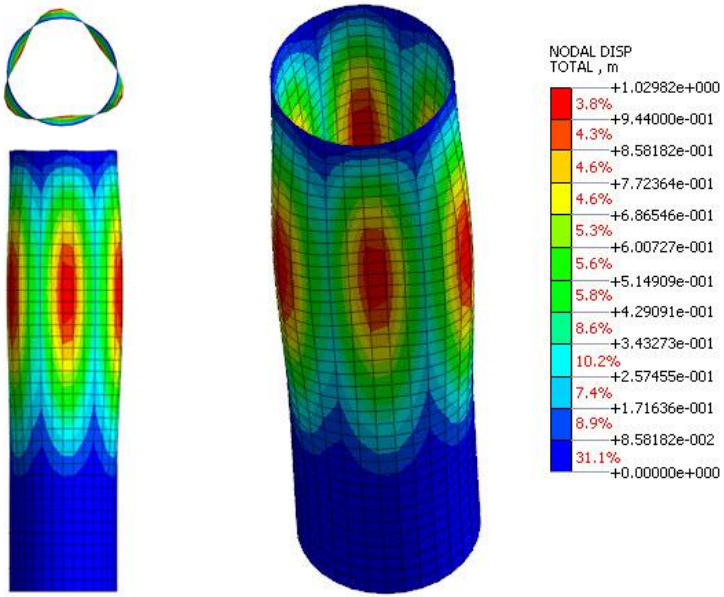

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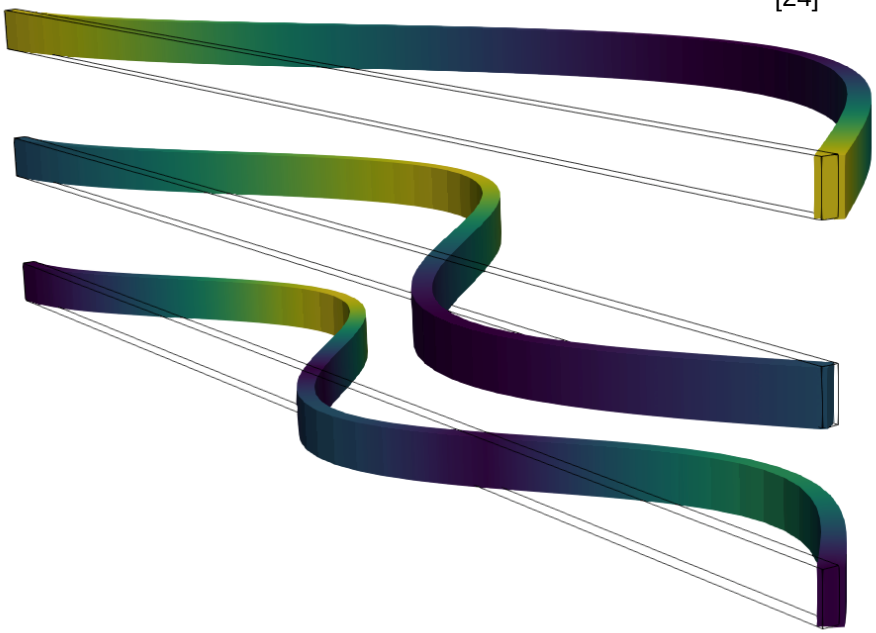

Plošni nosači

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doc. **Nina Čeh**
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Plošni nosači


[26]


[27]


[60]

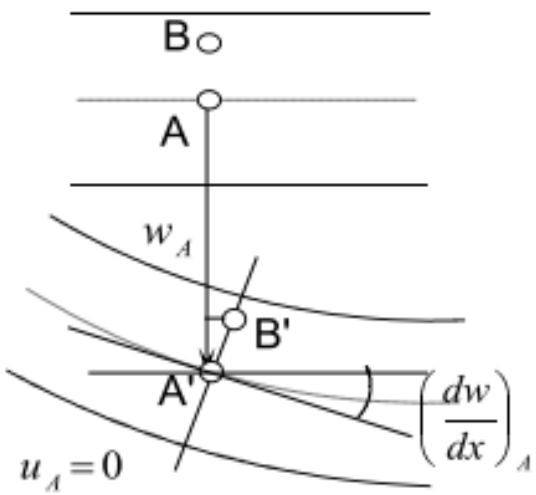

[28]

Različiti tipovi plošnih nosača u građevinarstvu: **stijene, membrane, ploče i ljuske.**

Plošni nosači

Koja je razlika između **grednih** i **plošnih** nosača?

Gredni nosač

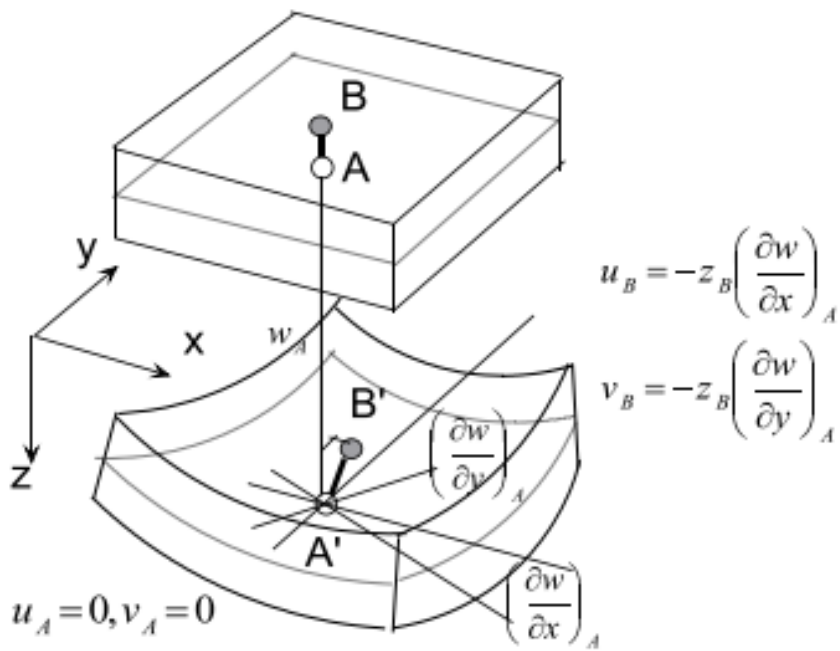


$$w_B = w_A$$

$$u_B = -z\left(\frac{dw}{dx}\right)_A$$

Pomaci svih točaka određeni su pomacima neutralne osi

Ploča



Pomaci svih točaka određeni su pomacima neutralne **ravnine**

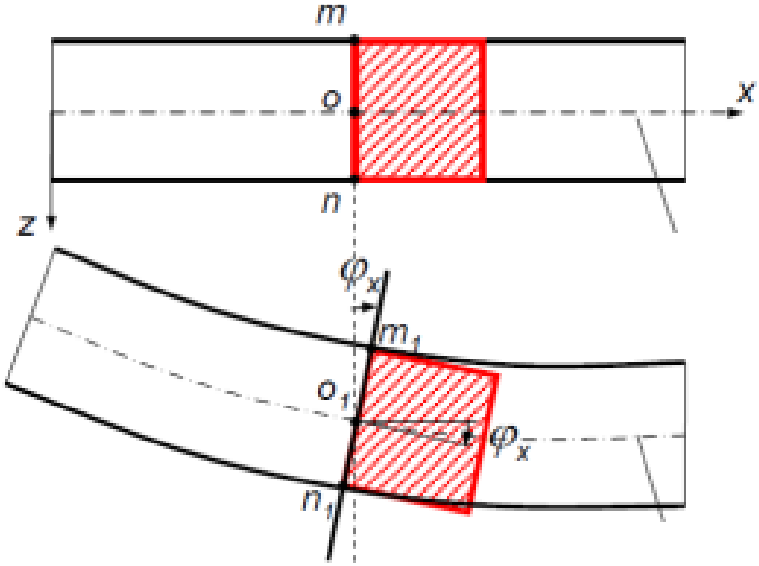
Plošni nosači

Po čemu se razlikuju **tanke** i **debele (visoke) ploče**?

Bernouli I + II: Kirchhoff

$$\varphi_x = \frac{\partial w}{\partial x} \quad \varphi_y = \frac{\partial w}{\partial y}$$

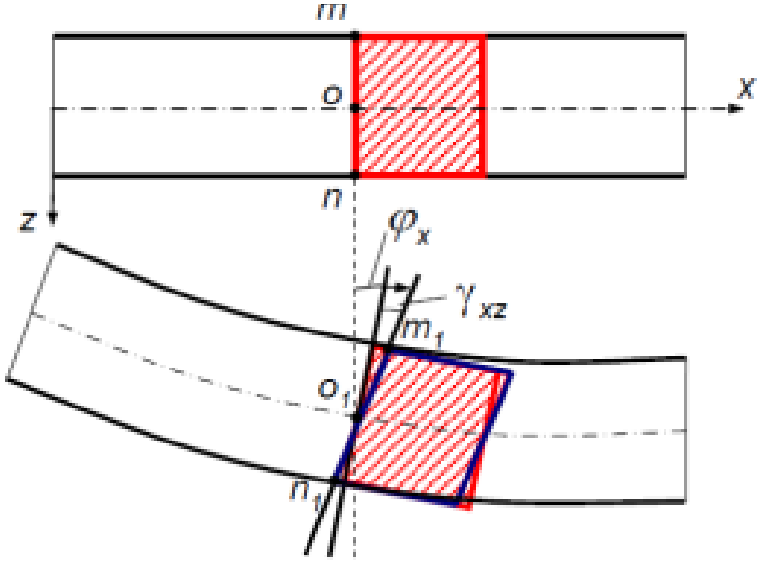
Posmična deformacija se zanemaruje



Bernouli I: Reissner-Mindlin

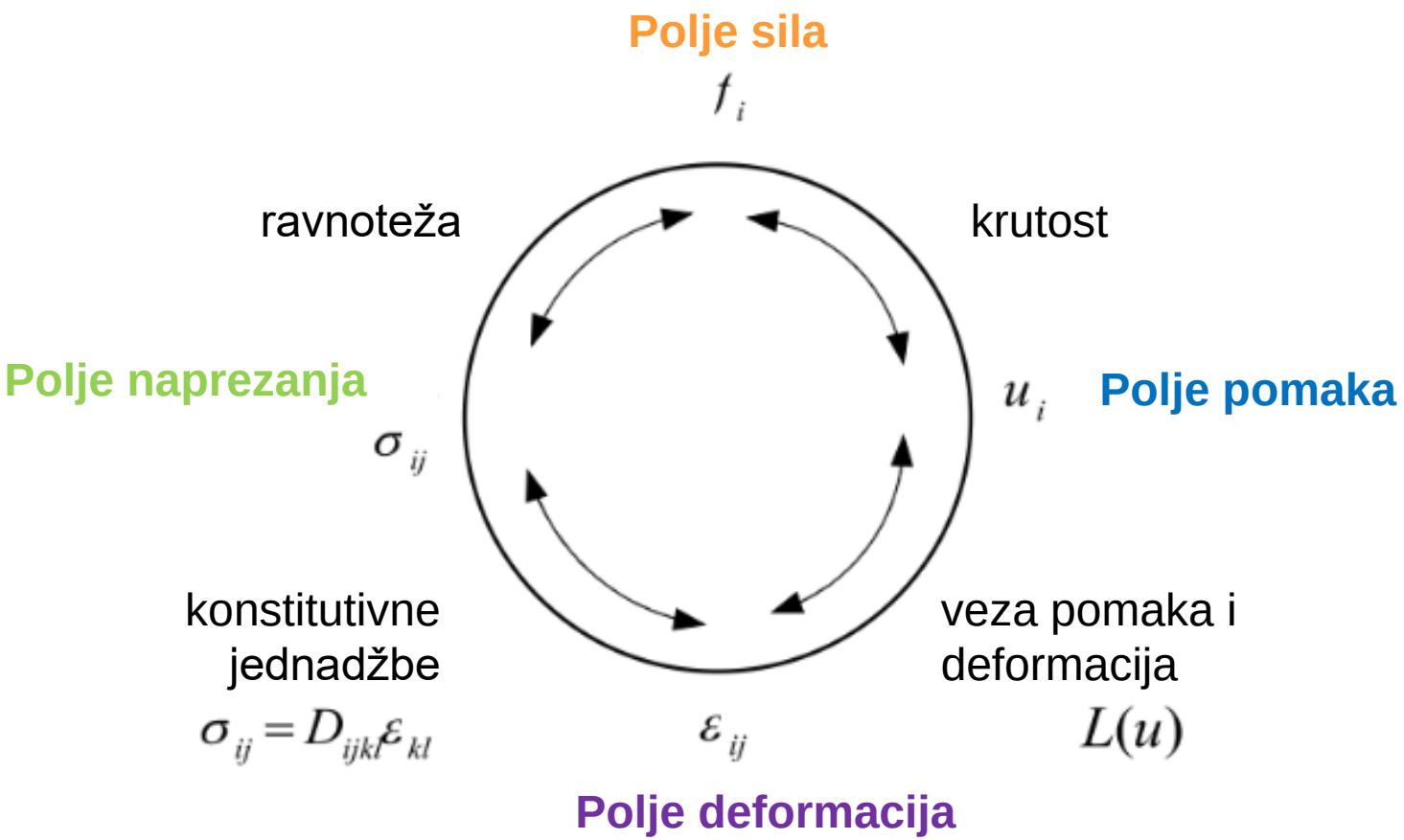
$$\varphi_x = \frac{\partial w}{\partial x} + \gamma_{xz} \quad \varphi_y = \frac{\partial w}{\partial y} + \gamma_{yz}$$

Posmična deformacija se **NE** zanemaruje



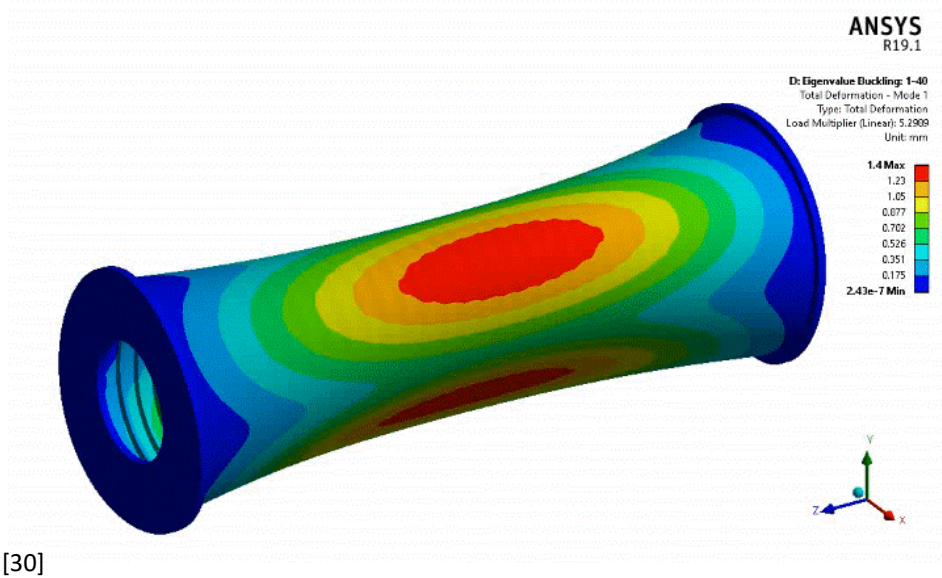
Plošni nosači

Kako su povezani **sila**, **pomak**, **deformacije** i **naprezanja**?



Plošni nosači

Upoznavanje sa numeričkim procedurama za statičku i dinamičku analizu plošnih nosača – **metoda konačnih razlika**, **Rayleigh-Ritz metoda** te **metoda konačnih elemenata**.



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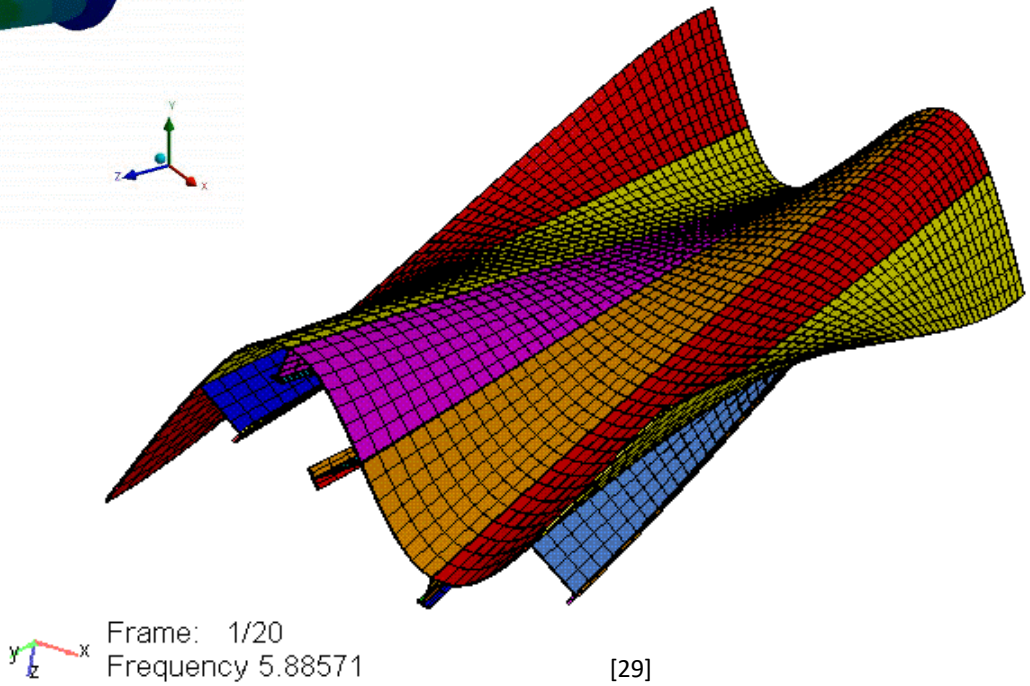

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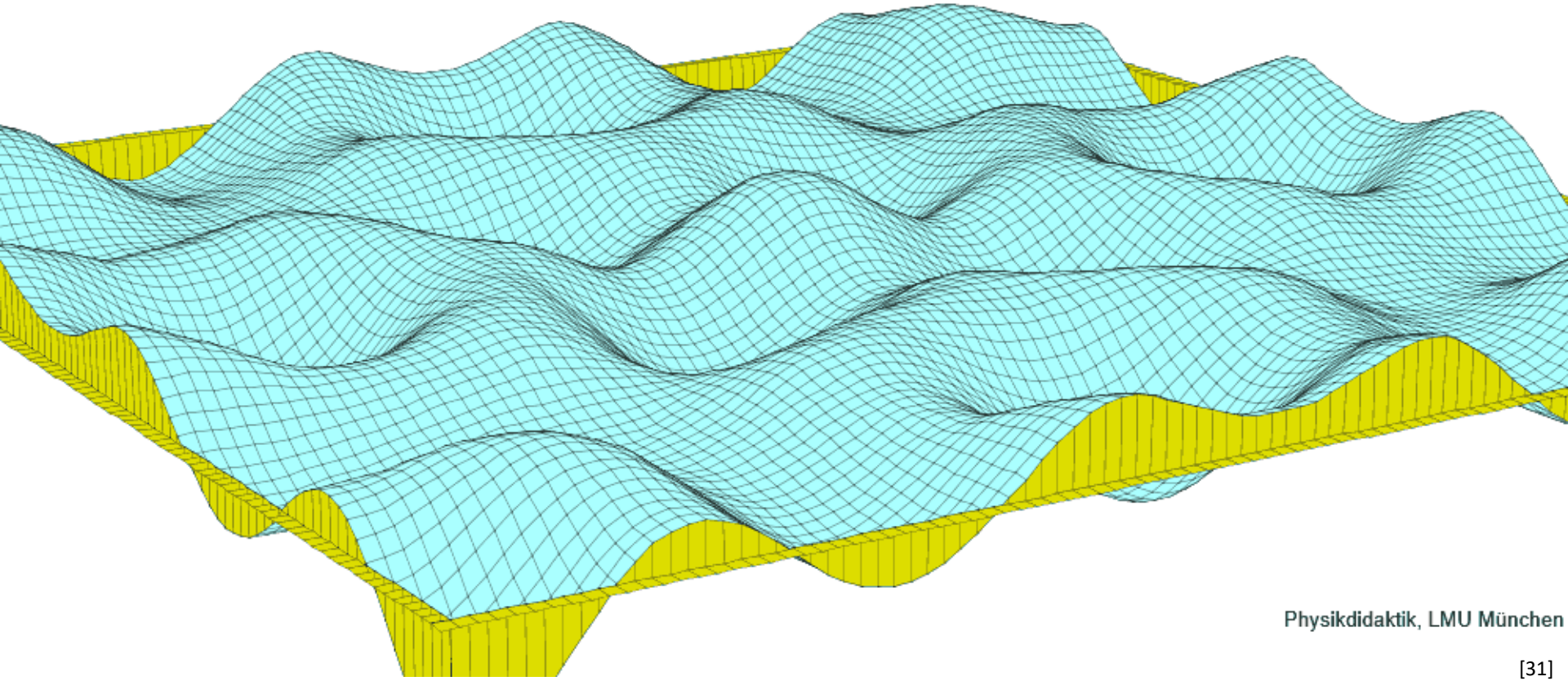
Plošni nosači

Upoznavanje sa numeričkim procedurama za statičku i dinamičku analizu plošnih nosača – **metoda konačnih razlika**, **Rayleigh-Ritz metoda** te **metoda konačnih elemenata**.



[31]

doc. **Teo Mudrić**
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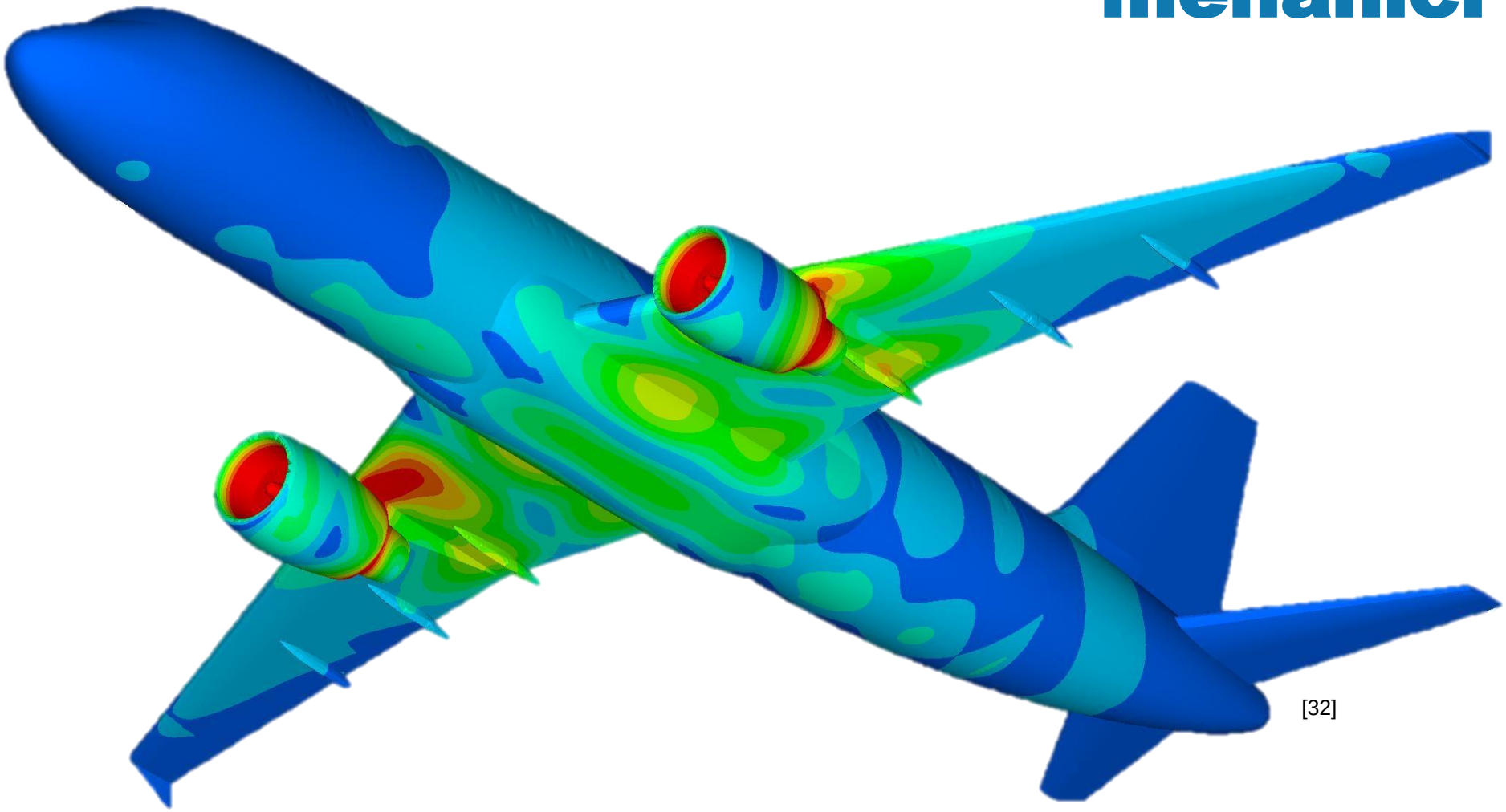
Energetske metode u primijenjenoj mehanici



[32]

Energetske metode u primijenjenoj mehanici

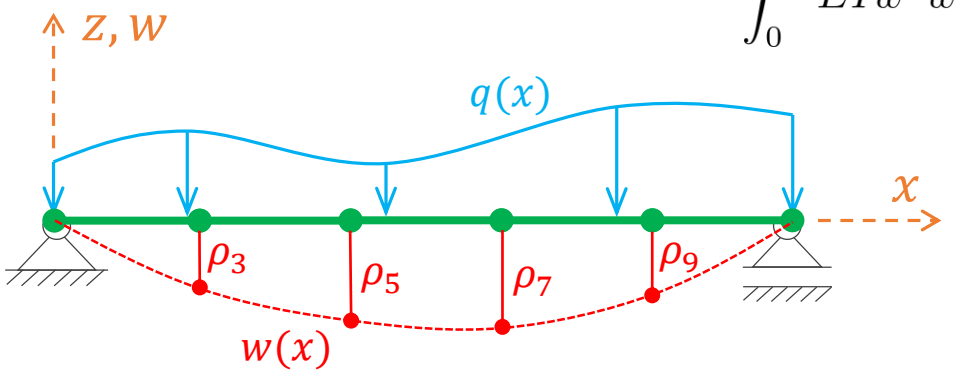
Jaka forma jednadžbe kojom opisujemo problem

$$EIw^{IV} = q$$

$$w(0) = 0$$
$$w(L) = 0$$
$$w''(0) = 0$$
$$w''(L) = 0$$

Slaba forma jednadžbe kojom opisujemo problem

$$\int_0^L EIw''\bar{w}''\,dx - \int_0^L q\bar{w}''\,dx = 0$$

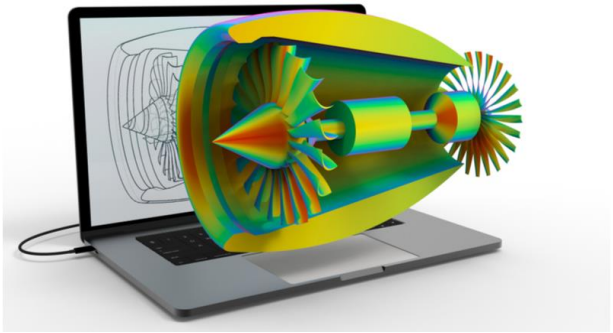


Približno rješenje jednadžbe problema metodom konačnih elemenata

$$\begin{bmatrix} k_{11} & k_{12} & \cdots & k_{1n} \\ k_{21} & k_{22} & \cdots & k_{2n} \\ \vdots & \vdots & \ddots & \\ k_{n1} & k_{n2} & & k_{nn} \end{bmatrix} \begin{bmatrix} \rho_1 \\ \rho_2 \\ \vdots \\ \rho_n \end{bmatrix} = \begin{bmatrix} F_1 \\ F_2 \\ \vdots \\ F_n \end{bmatrix}$$

$$\mathbf{K}\boldsymbol{\rho} = \mathbf{F} \;\rightarrow\; \boldsymbol{\rho} = \mathbf{K}^{-1}\mathbf{F}$$

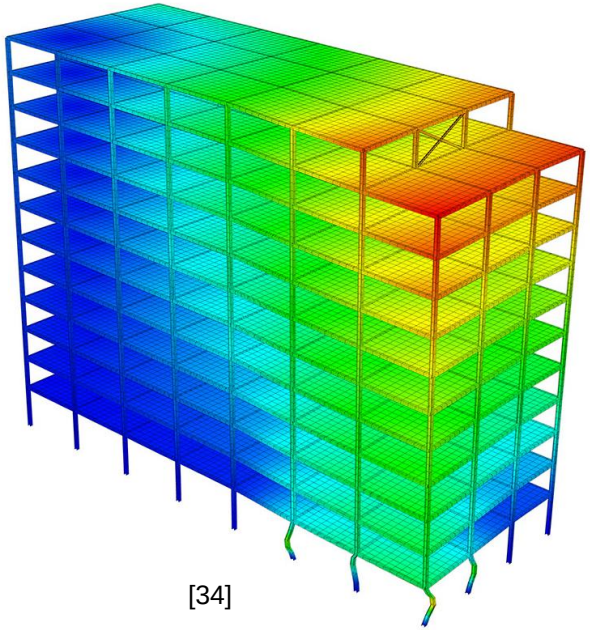
Praktična za implementaciju u računala (Metoda konačnih elemenata)



[33]

Biti će opisani postupci za dobivanje približnih rješenja koja zadovoljavaju slabu formu, posebice postupak metode konačnih elemenata

Energetske metode u primijenjenoj mehanici



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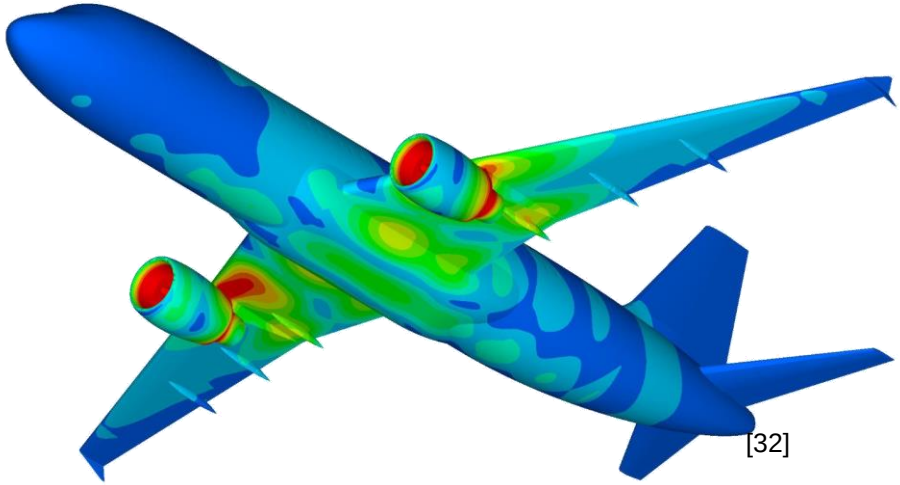

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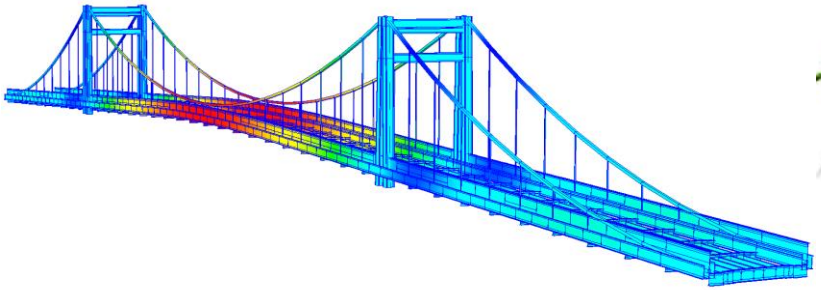

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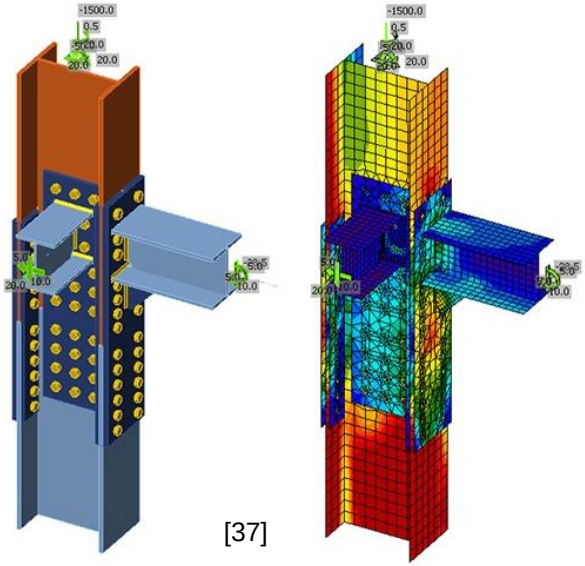

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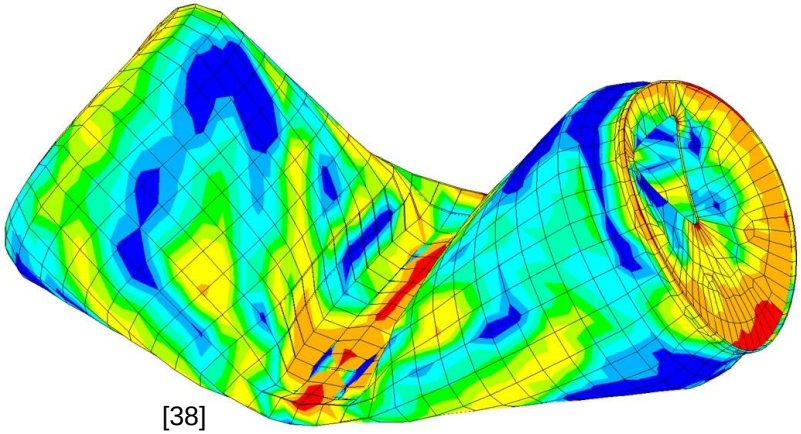
Pomoću softvera koji implementira Metodu konačnih elemenata moguće je analizirati širok spektar kompleksnih mehaničkih problema

Energetske metode u primijenjenoj mehanici



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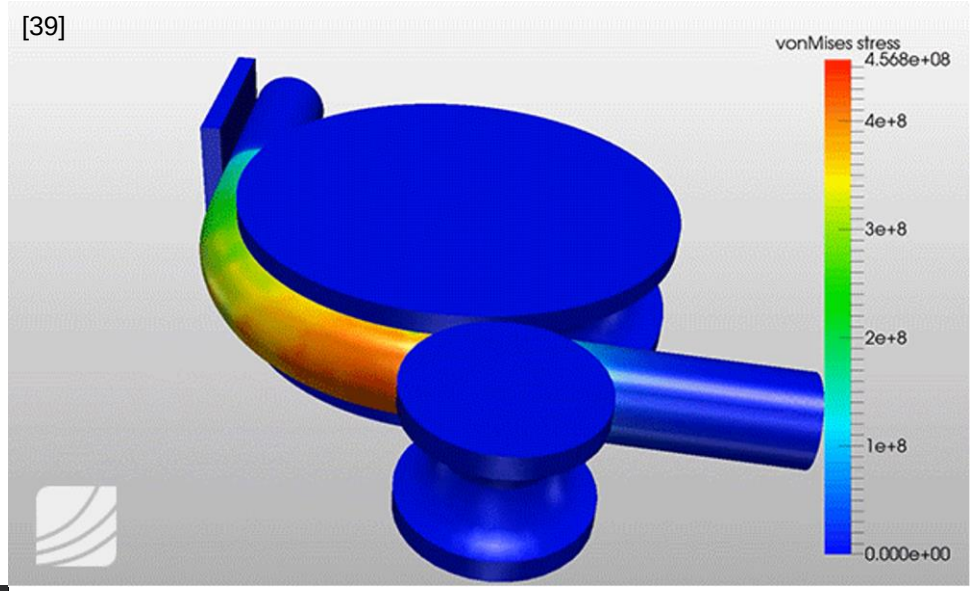

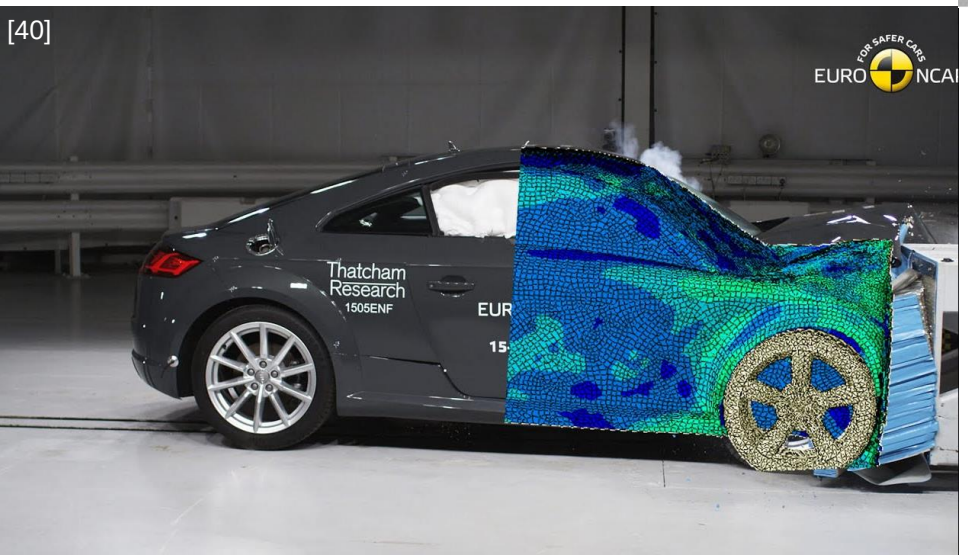

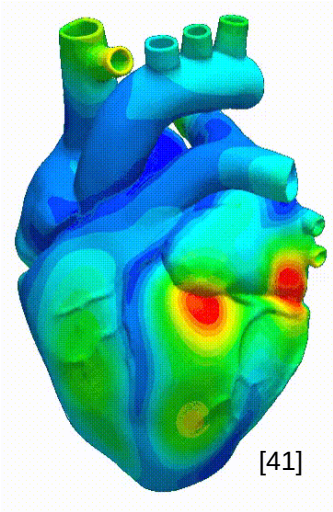

[41]

Pomoću softvera koji implementira Metodu konačnih elemenata moguće je analizirati širok spektar kompleksnih mehaničkih problema

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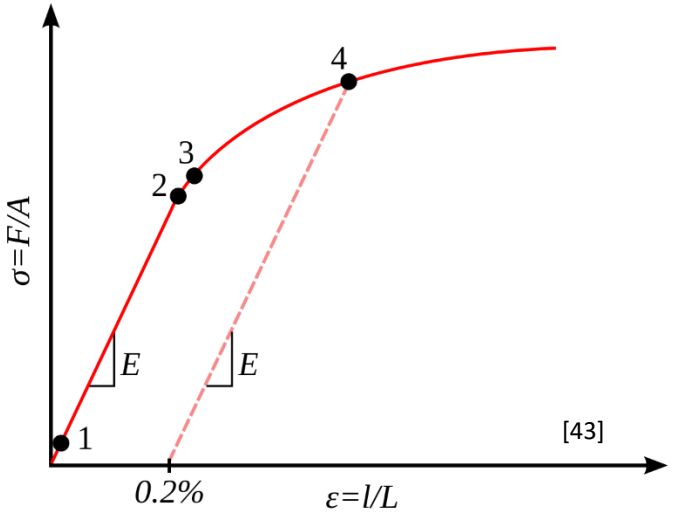
[42]

Uvod u modeliranje plastičnosti i oštećenja

Uvod u modeliranje plastičnosti i oštećenja

JEDNOOSNO STANJE NAPREZANJA

- Plastične deformacije



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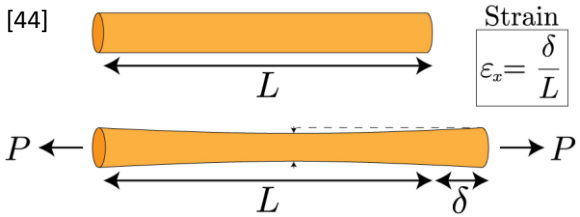

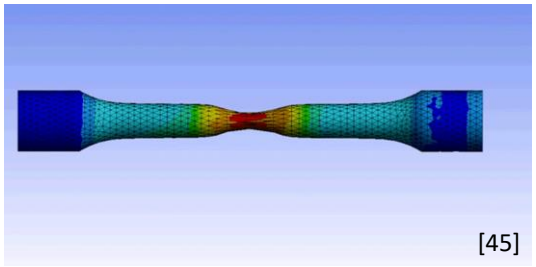

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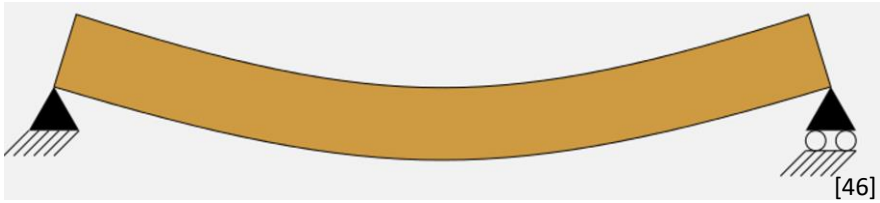
ELASTO-PLASTIČNO SAVIJANJE

- postepena plastifikacija poprečnog presjeka i otvaranje plastičnog zgloba



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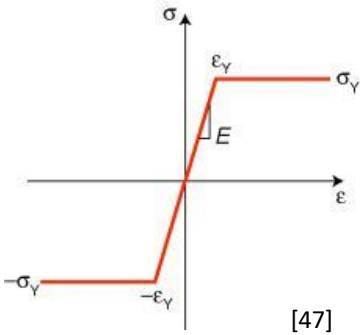
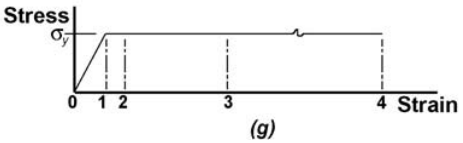


[47]

Prandtlov model



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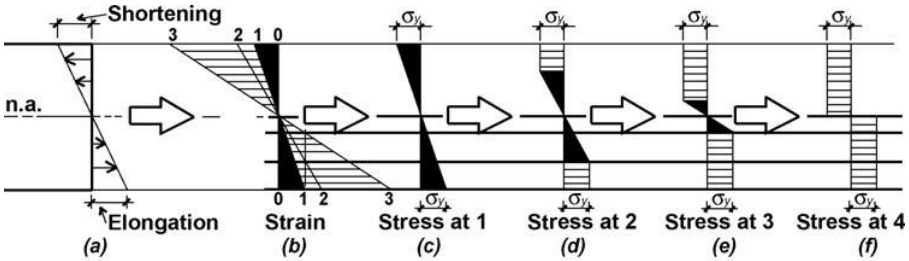
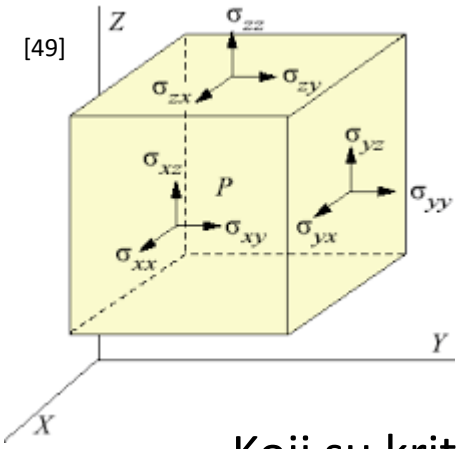
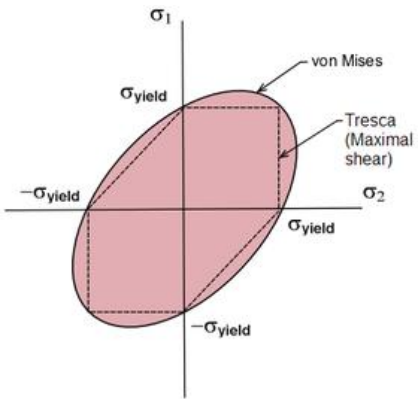


Uvod u modeliranje plastičnosti i oštećenja

VIŠEOSNO STANJE NAPREZANJA – kada nastupa tečenje/plastifikacija?

[49]





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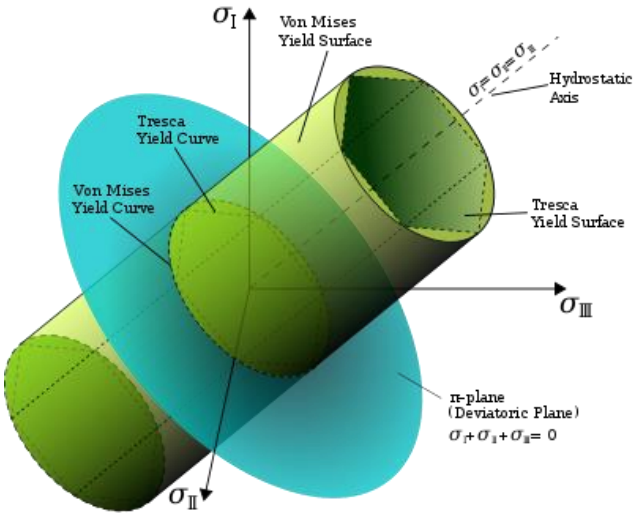
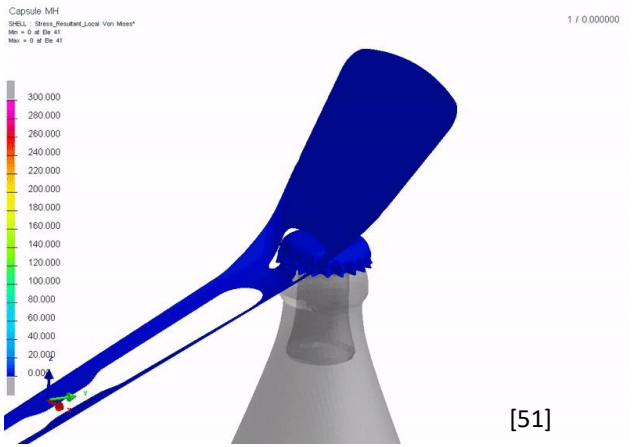


Koji su kriteriji za tečenje/plastifikaciju?

Primjena u računalnim simulacijama



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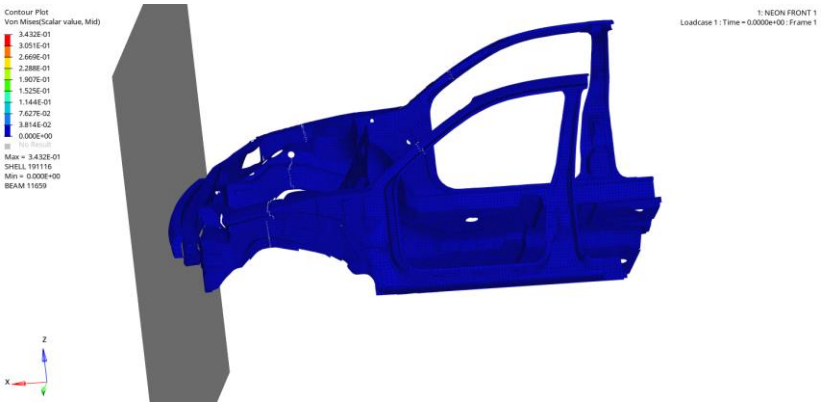
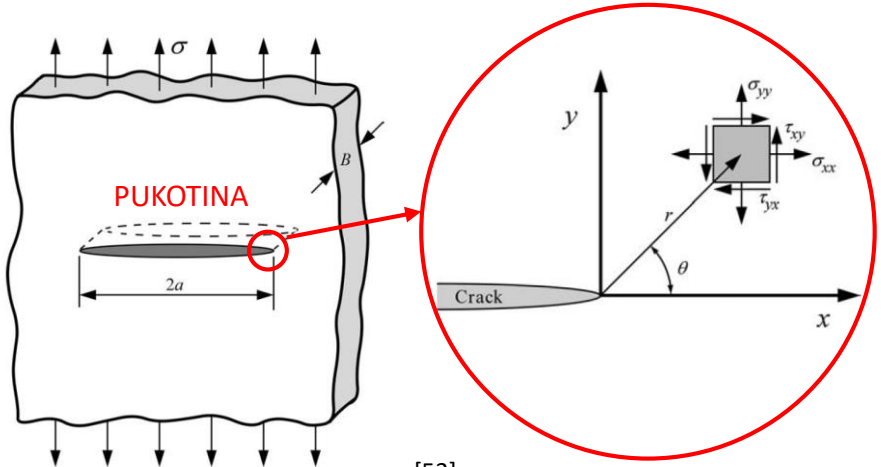


[52]

Uvod u modeliranje plastičnosti i oštećenja

MEHANIKA LOMA – kada i zašto nastaje pukotina u materijalu?



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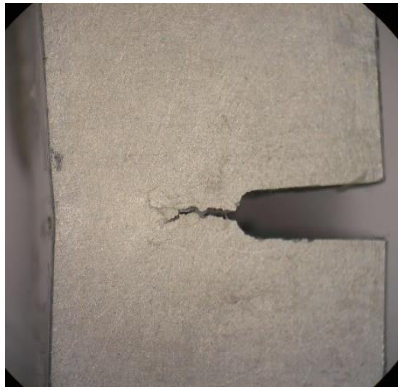

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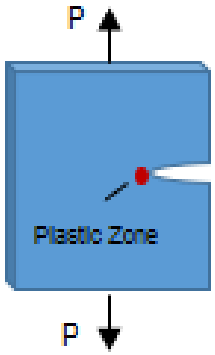
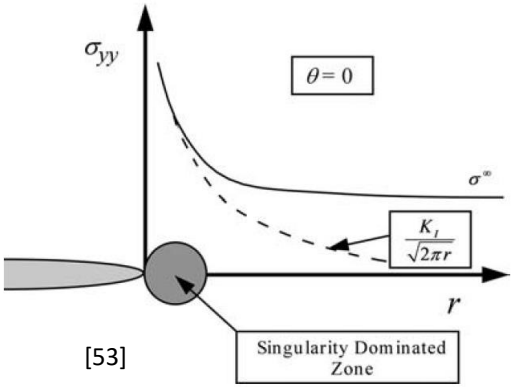


[56]

Linearno-elastična mehanika loma – krti slom materijala

Duktilni slom materijala - iza pukotine formira se plastična zona (oštećenje)



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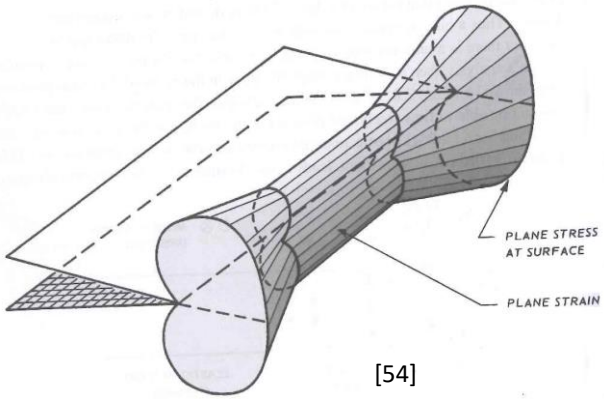
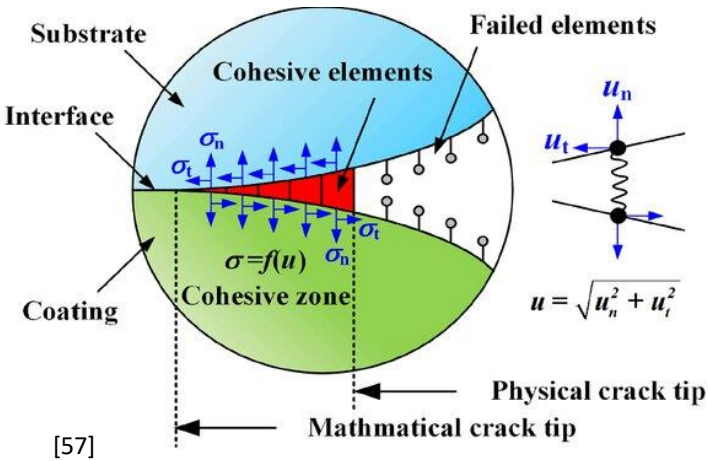


[54]

Uvod u modeliranje plastičnosti i oštećenja

MEHANIKA OŠTEĆENJA

- Modeli progresivnog oštećenja (omekšanja) koji dovode do sloma materijala



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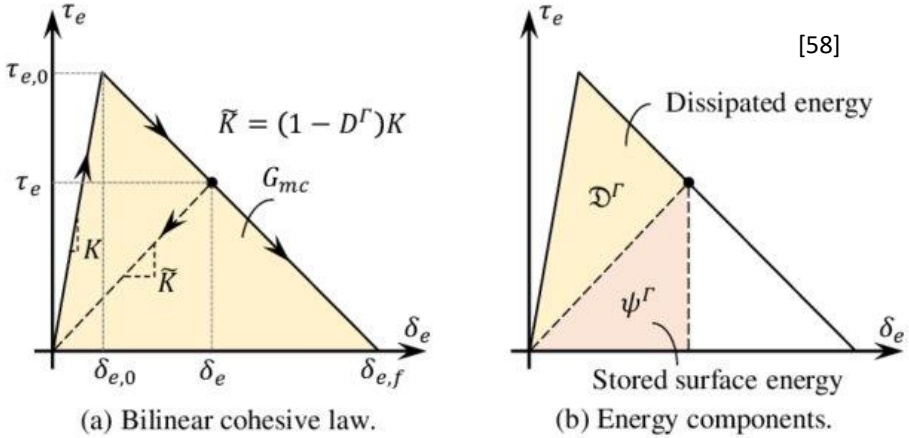
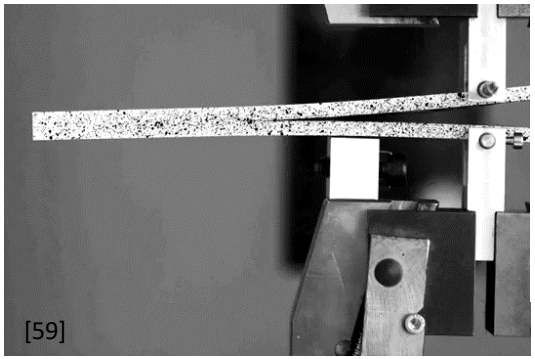


[58]

Eksperimentalno određivanje parametara koji opisuju lomnu otpornost materijala



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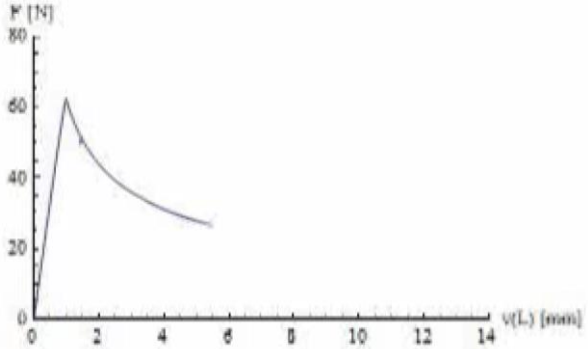

PRIMIJENJENA MEHANIKA U SUVREMENOJ INŽENJERSKOJ PRAKSI

Detaljan opis predmeta na *www.gradri.hr*:
https://gradri.uniri.hr/wp-content/uploads/2023/07/Diplomski-sveucilisni-2023-svibanj.pdf

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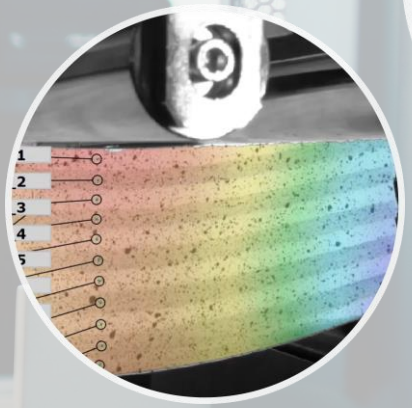
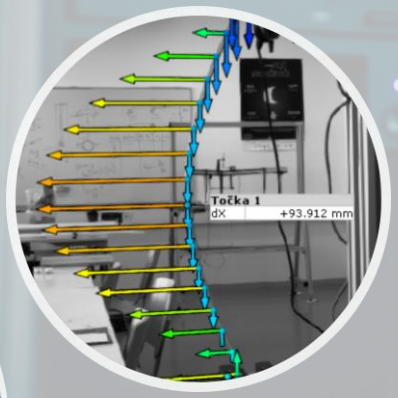
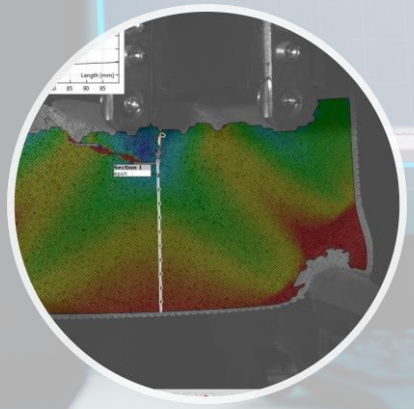
NAPOMENA: Moguće je upisati samo dio predmeta mikrokvalifikacije, ali se onda ne stječe mikrokvalifikacija.

PRIMIJENJENA MEHANIKA U SUVREMENOJ INŽENJERSKOJ PRAKSI







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