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MODELLO DI TENUTA DELLA FLANGIA BULLONATA SENZA GUARNIZIONE PER COMPRESSORI CENTRIFUGHI

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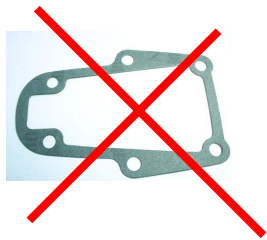
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General Electric, Oil & Gas, Firenze



Flange di grosse dimensioni senza guarnizione

Compressore centrifugo



Sigillante (silicone)
Metal-to-Metal

Flangia bullonata
senza guarnizione

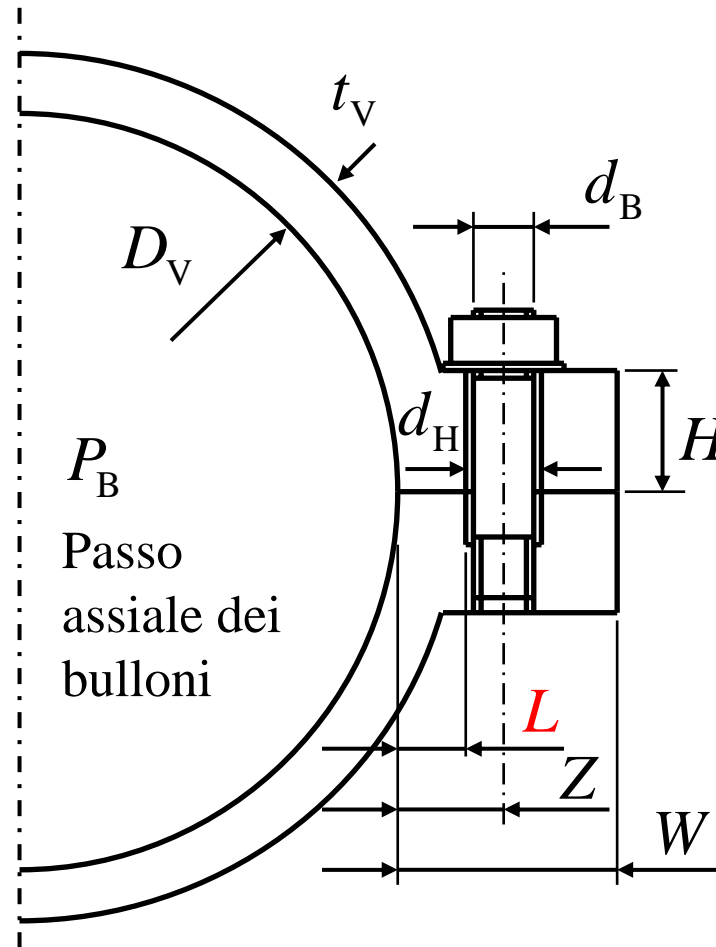
Obiettivo del lavoro:

- Modello di tenuta per prevedere la **pressione di perdita**
(Meccanica della Frattura)

Validazioni:

- Modello EF
- Sperimentale in **piena scala**
- Sperimentale in **scala ridotta**

Geometria della flangia bullonata



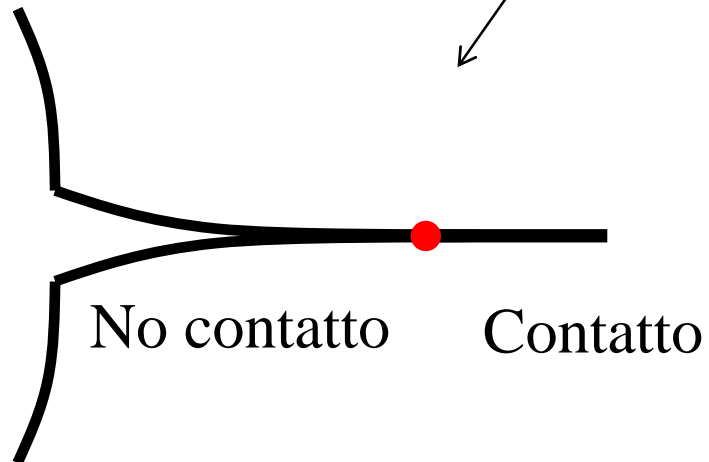
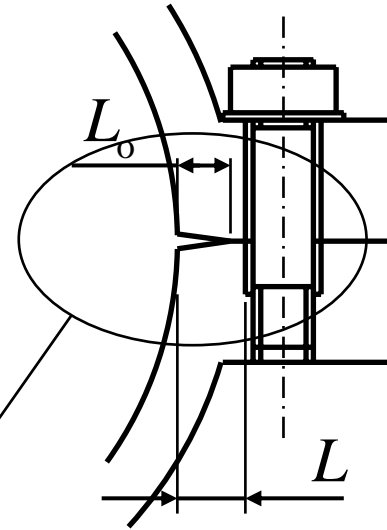
Condizione di perdita

Nessuna perdita:

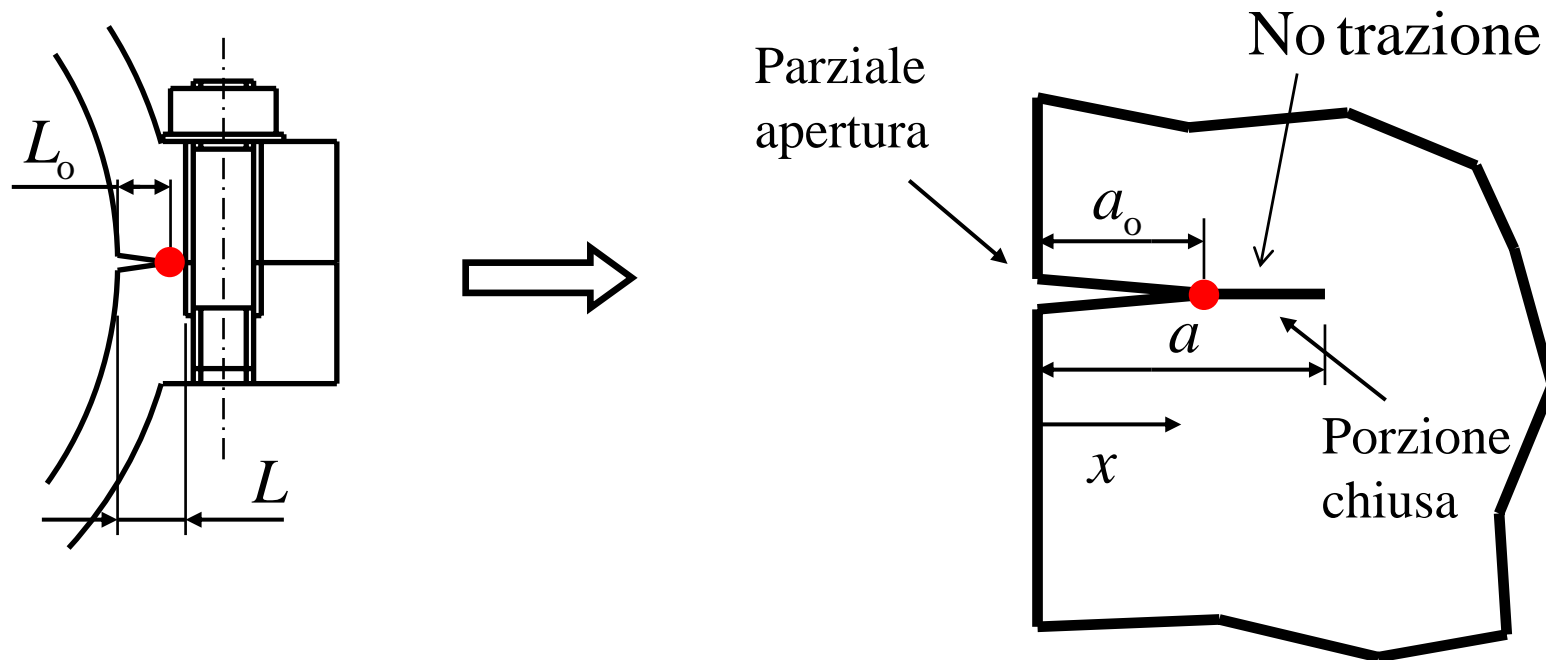
$$L_o < L,$$

Perdita:

$$L_o = L$$



Similitudine fra Flangia e Fessura parzialmente aperta

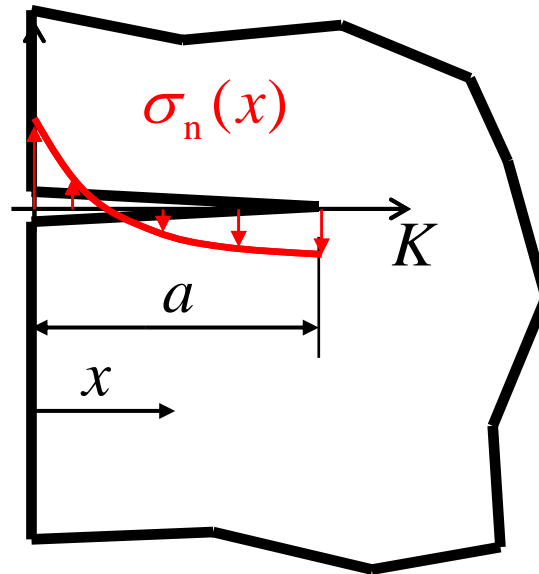


Fessure parzialmente aperte :

Fattore di Intensificazione delle Tensioni NULLO

$$K = 0$$

Weight functions (Funzione peso)

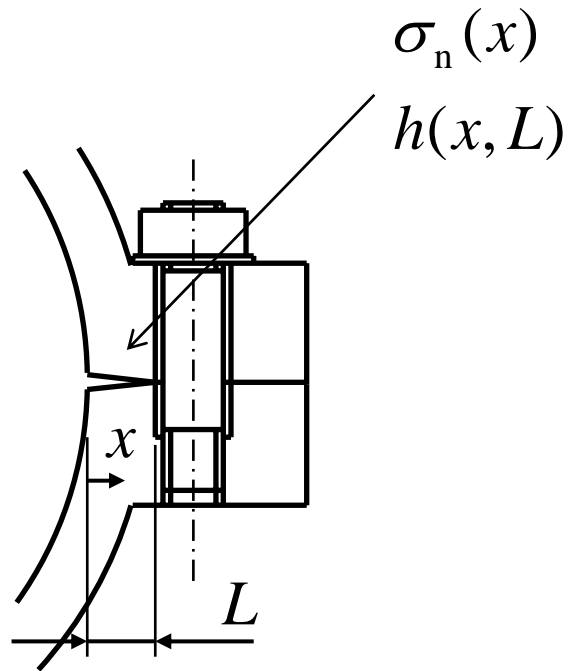


Distribuzione di tensione
"nominale"

Weight function

$$K = \int_0^a \sigma_n(x) h(x, a_0) dx$$

Applicazione al problema della flangia



$$\sigma_n(x) = ?$$

$$h(x, L) = ?$$

Formalizzazione della condizione di perdita:

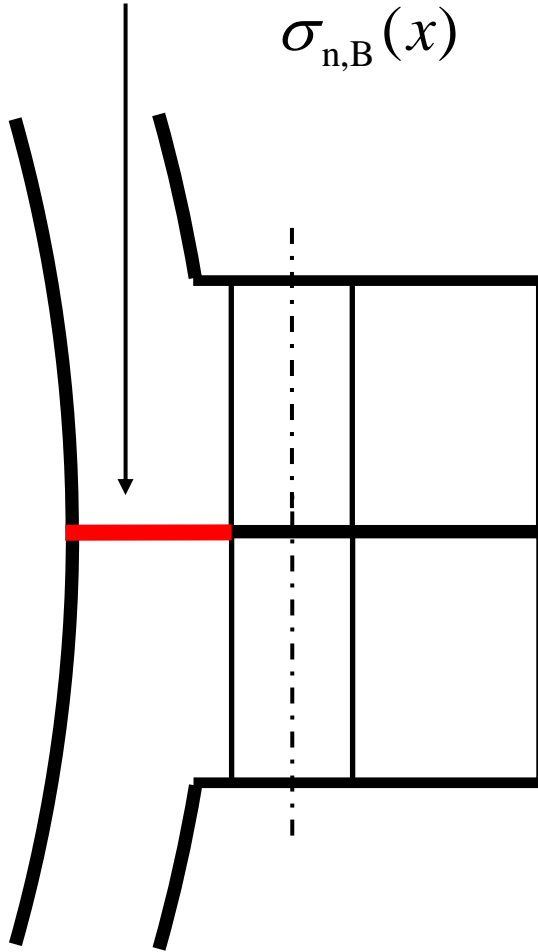
$$K = 0, \quad L_0 = L$$

$$\int_0^L \sigma_n(x) h(x, L) dx = 0$$

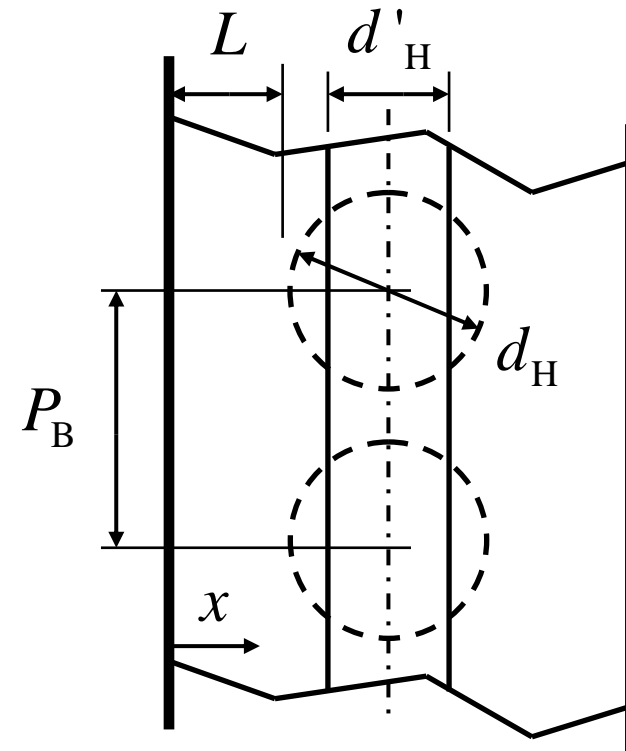
Componenti di tensione nominale

$$\sigma_n(x) = \sigma_{n,p}(x) + \text{(generata dalla pressione interna)}$$

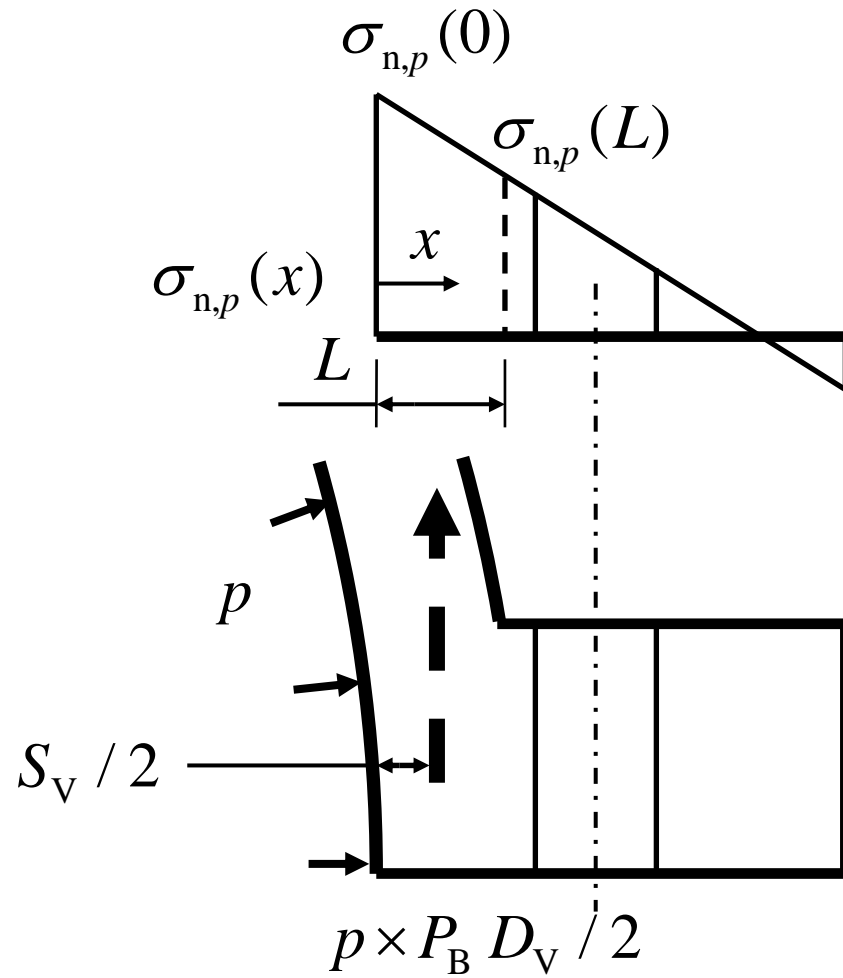
$$\sigma_{n,B}(x) \quad \text{(generata dal preserraggio dei bulloni)}$$



Approssimazione: schema piano



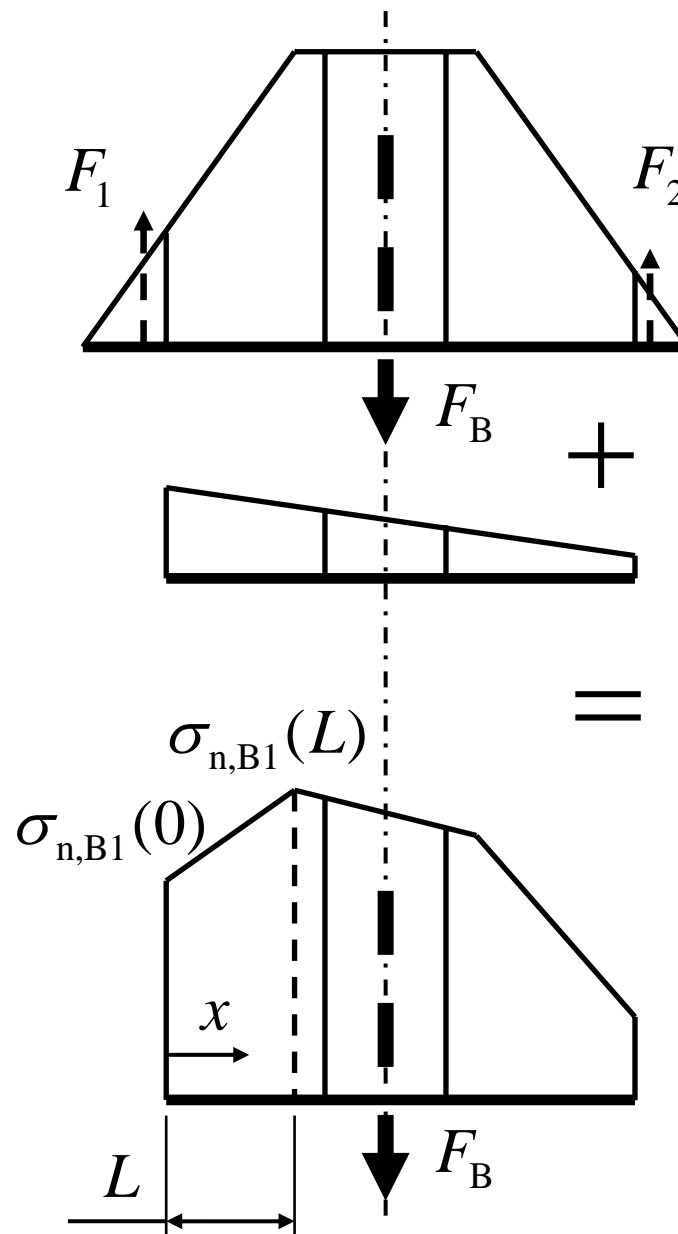
Tensione nominale generata dalla pressione interna (trazione)



Appr.:
distribuzione lineare

Tensione nominale generata dal preserraggio dei bulloni (compressione)

Appr.:
*distribuzione
lineare*

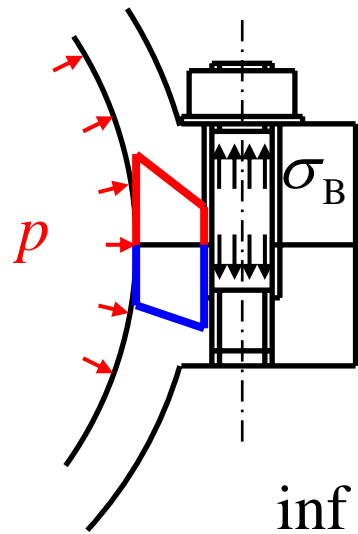


Larghezza della
distribuzione,
maggiore della flangia

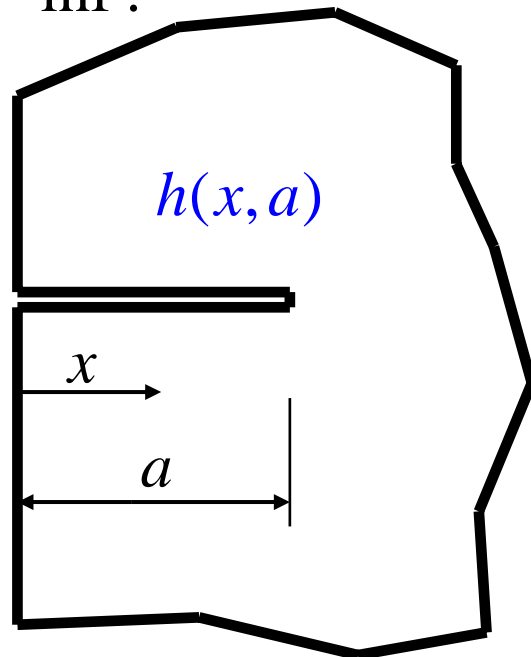
Distribuzione di pressione
equivalente alle due forze:
 F_1, F_2

Distribuzione
risultante

Weight function, fessura in un semispazio

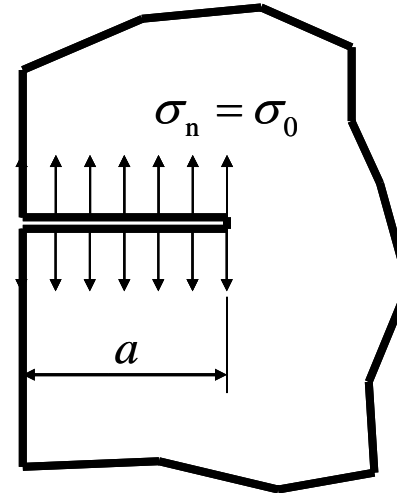


*distribuzioni
lineari*

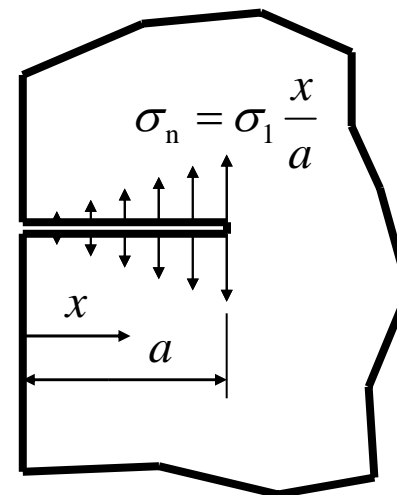


inf .

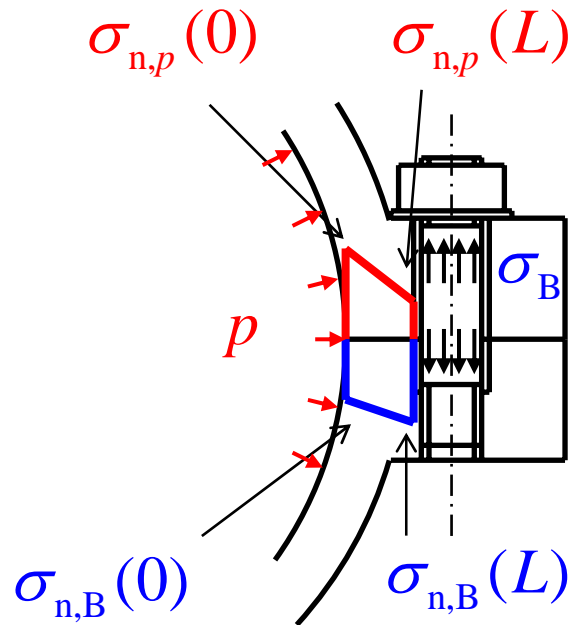
$$K_0 = 1.1215 \sigma_0 \sqrt{\pi a}$$



$$K_1 = 0.6820 \sigma_1 \sqrt{\pi a}$$



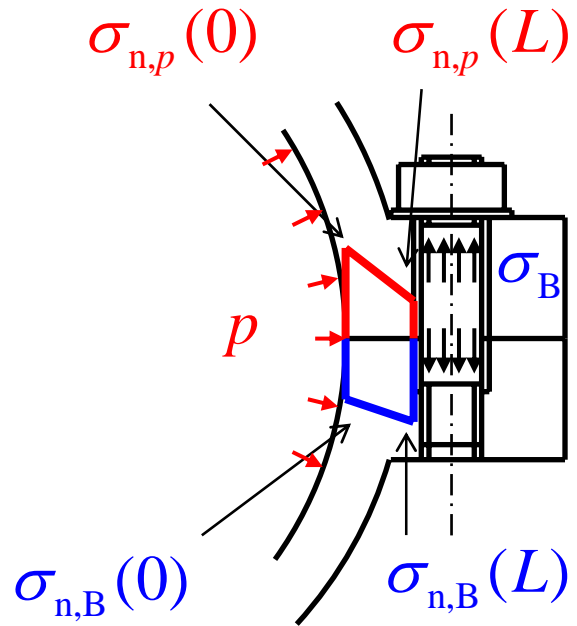
Modello analitico



$$\int_0^L \sigma_{n,p}(x) h(x) dx = \int_0^L \sigma_{n,p}(0) h(x) dx + \int_0^L [\sigma_{n,p}(L) - \sigma_{n,p}(0)] \frac{x}{L} h(x) dx$$

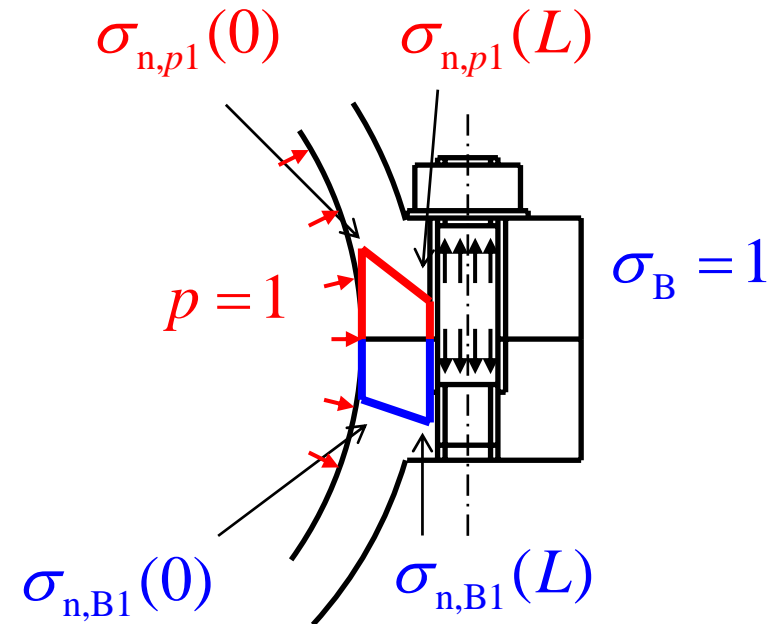
$$\int_0^L \sigma_{n,B}(x) h(x) dx = \int_0^L \sigma_{n,B}(0) h(x) dx + \int_0^L [\sigma_{n,B}(L) - \sigma_{n,B}(0)] \frac{x}{L} h(x) dx$$

Modello analitico

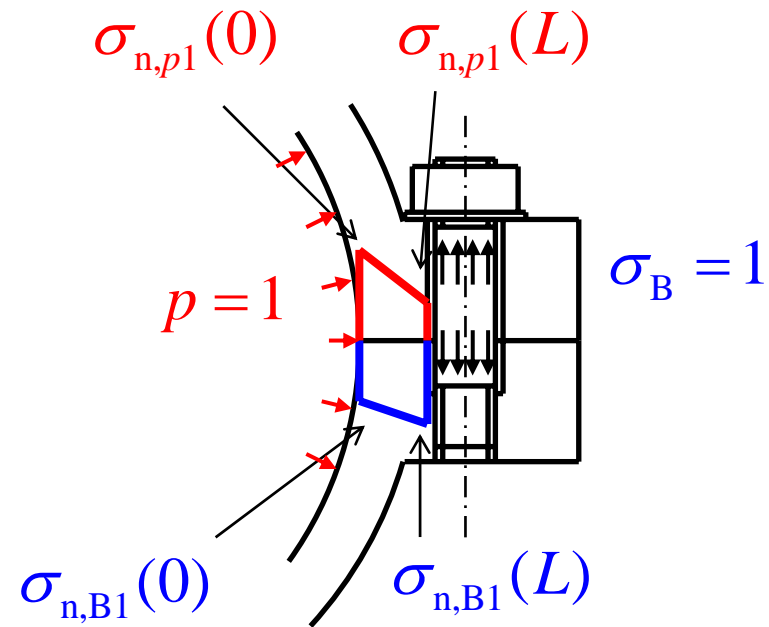


$$\sigma_{n,p}(x) = p \times \sigma_{n,p1}(x)$$

$$\sigma_{n,B}(x) = \sigma_B \times \sigma_{n,B1}(x)$$

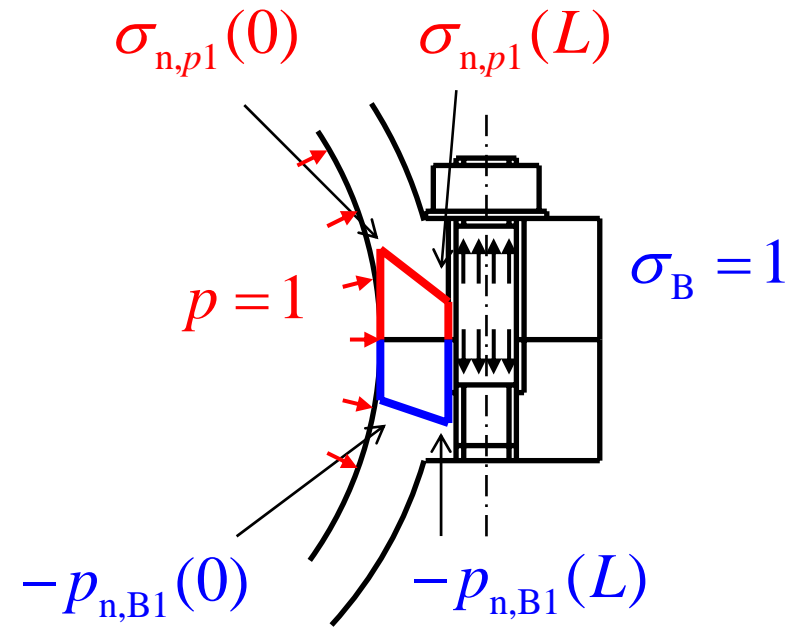


Modello analitico



$$p_L = -\sigma_B \frac{\sigma_{n,B1}(0) + 1.55 \sigma_{n,B1}(L)}{\sigma_{n,p1}(0) + 1.55 \sigma_{n,p1}(L)}$$

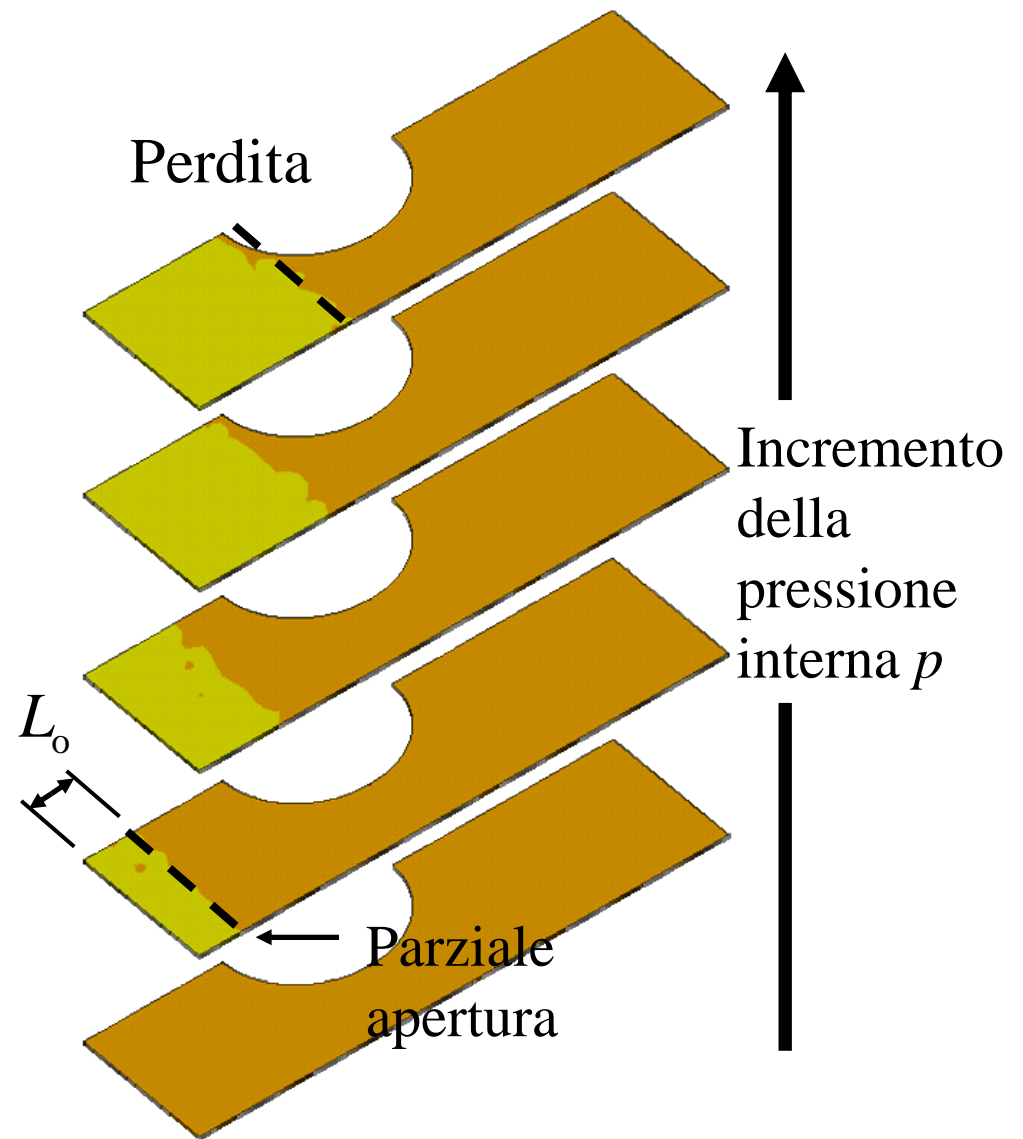
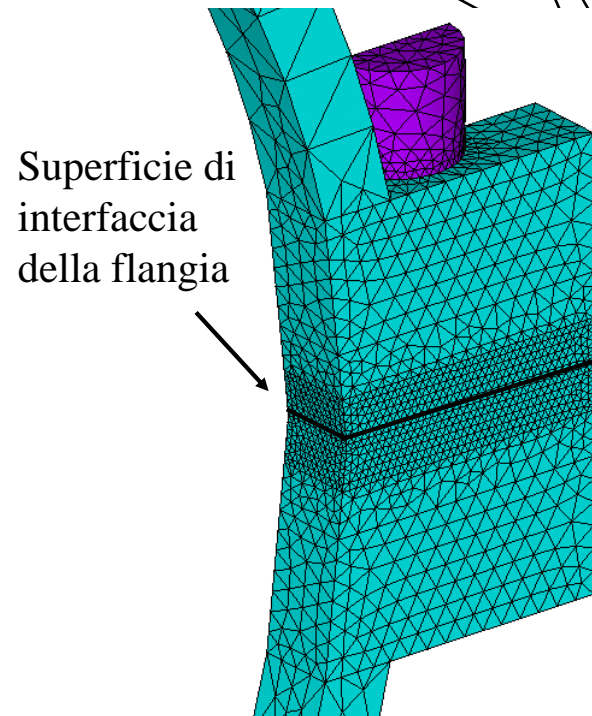
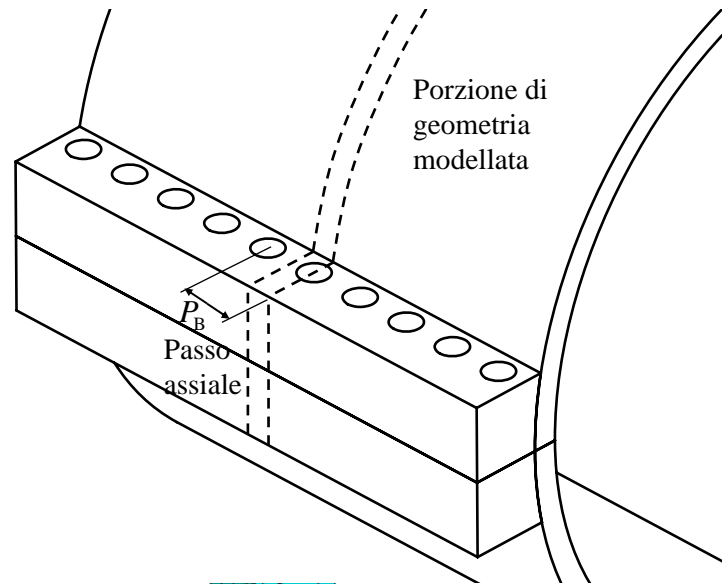
Modello analitico



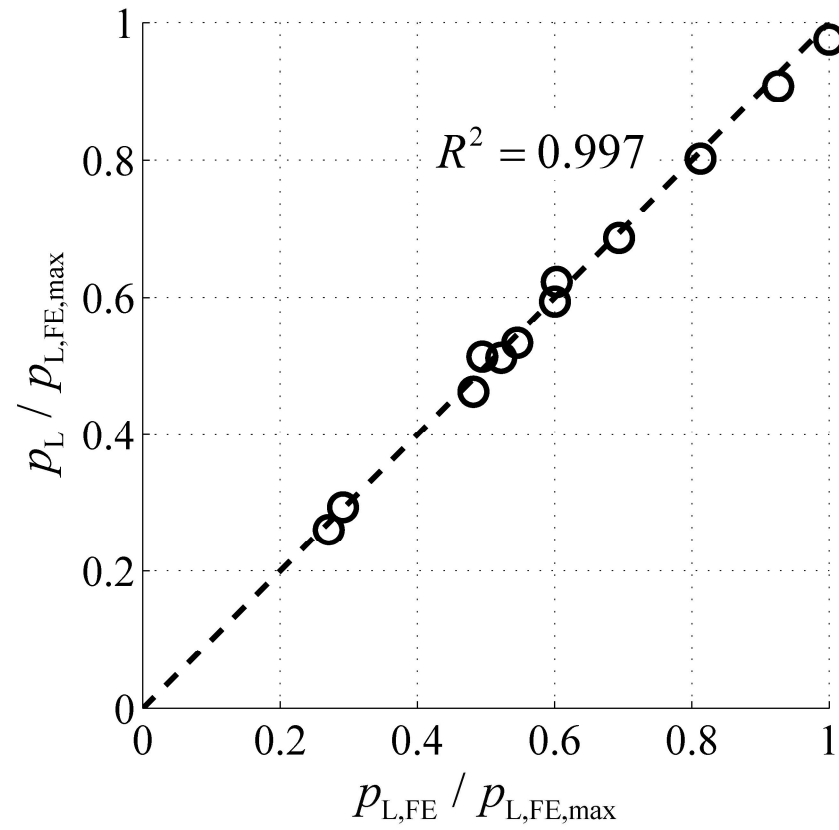
$$p_{n,B}(x) = -\sigma_{n,B}(x)$$

$$p_L = \sigma_B \frac{p_{n,B1}(0) + 1.55 p_{n,B1}(L)}{\sigma_{n,p1}(0) + 1.55 \sigma_{n,p1}(L)}$$

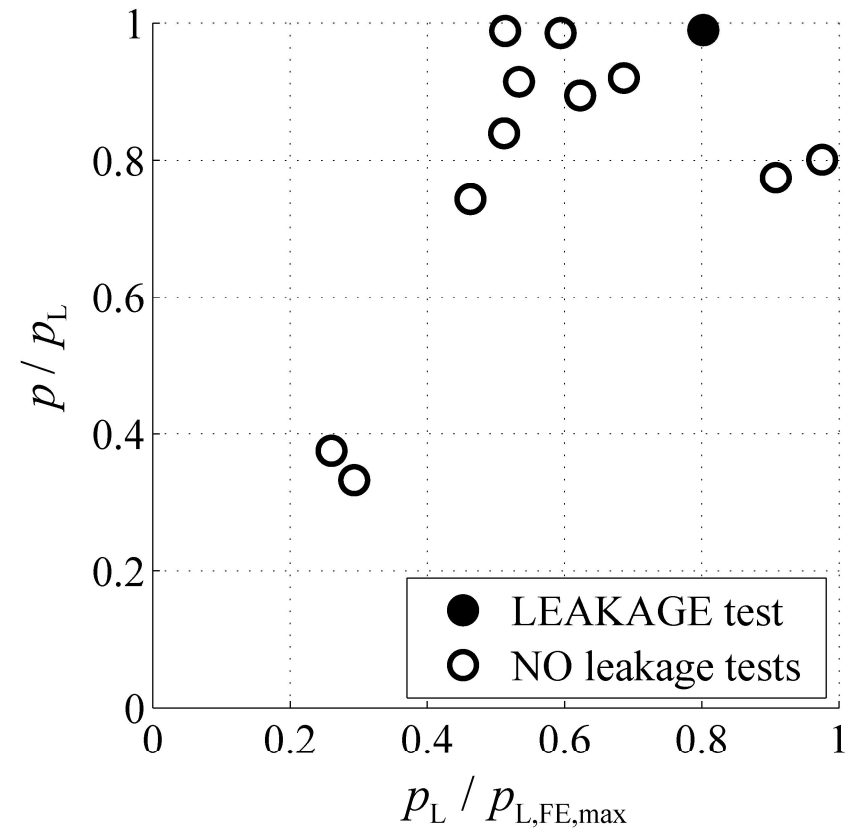
Validazione EF



Validazione EF

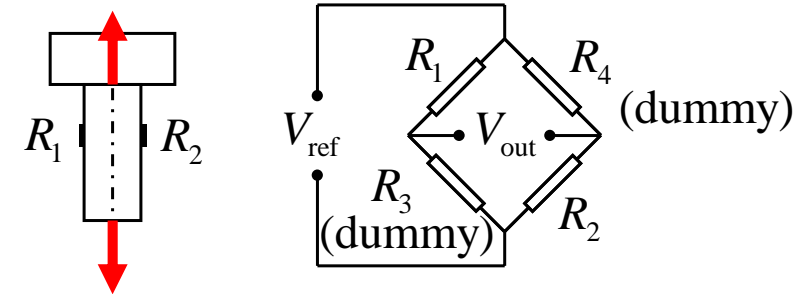
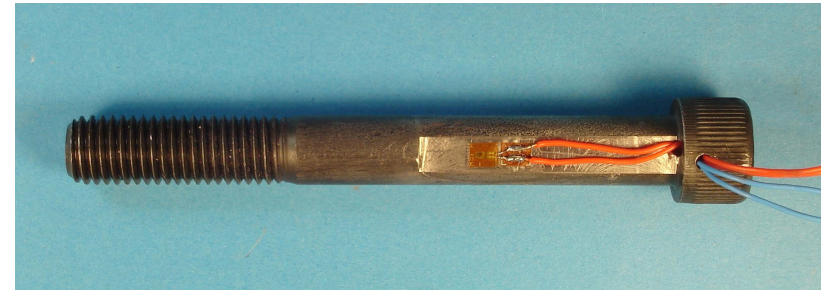
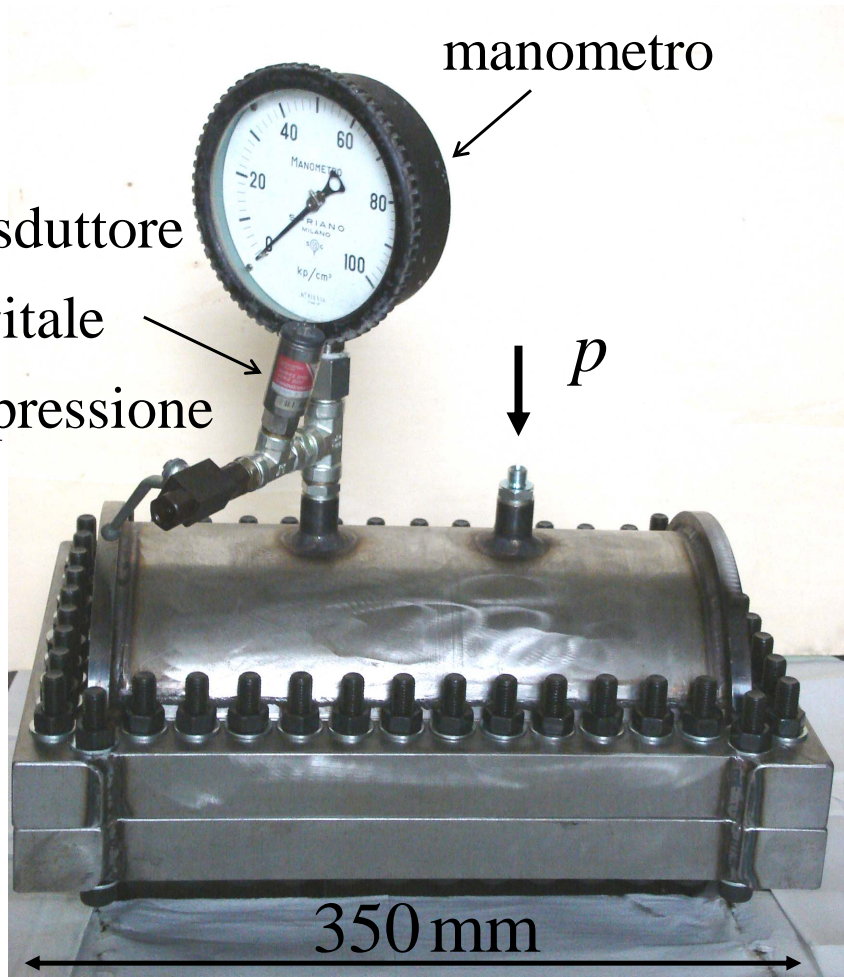


Prove di pressurizzazione su componenti in piena scala

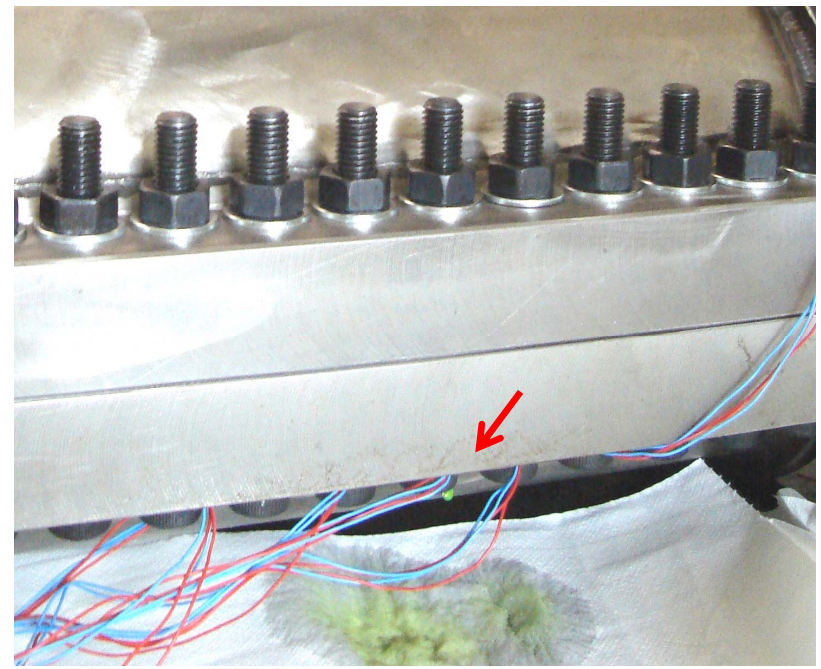


Validazione: prove in scala ridotta

manometro
trasduttore
digitale
di pressione



$p \uparrow$



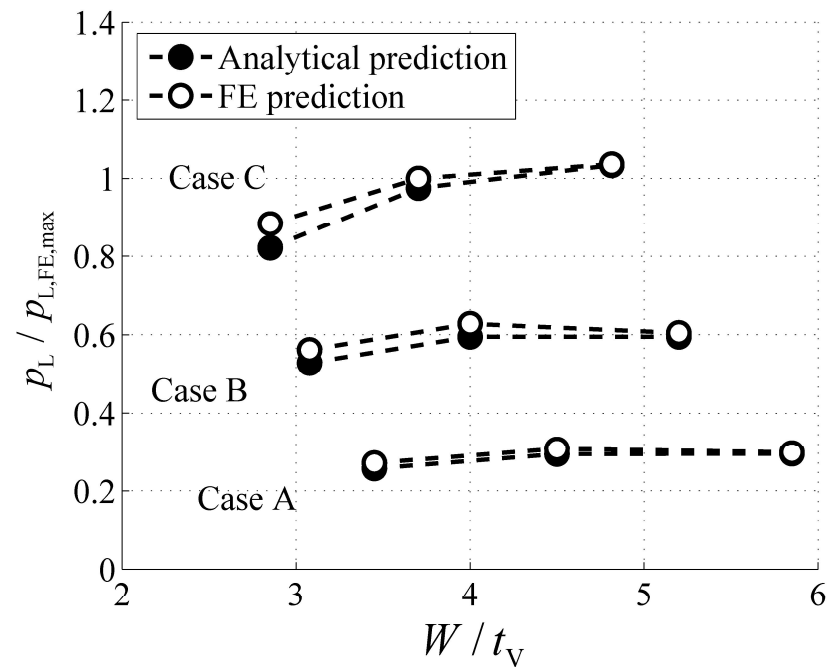
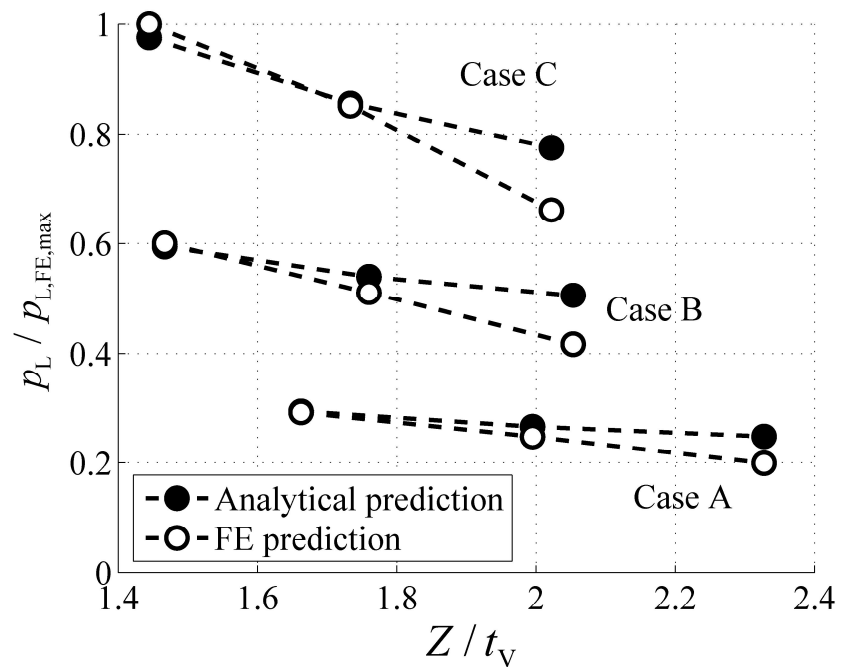
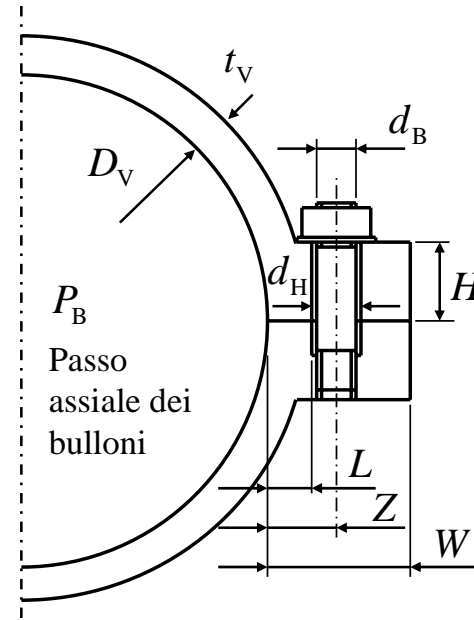
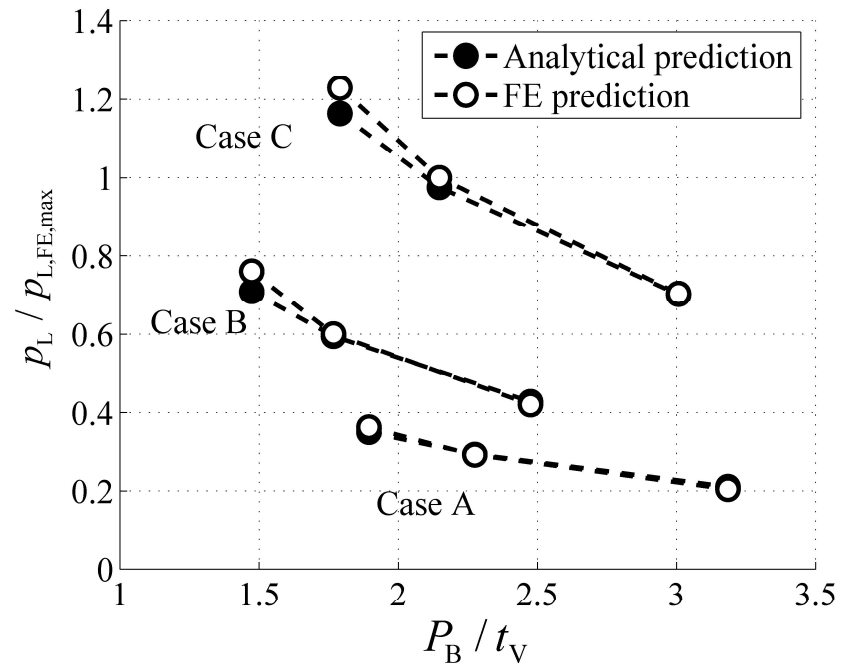
Validazione: prove in scala ridotta

Risultati preliminari

Test	Precarico bullone [kN]	Pressione di perdita* <i>sperimentale</i> [bar]	Pressione di perdita <i>modello</i> [bar]	Errore percentuale
1	30.7	63	59	6 %
2	20.2	41	41	< 1 %
3	20.1	43	41	6 %
4	20.4	41	41	< 1 %
5	30.5	57	61	7 %

* Portata di perdita > 15×10^{-3} g/sec

Linee guida di progetto



Sommario e Conclusioni

- È stato presentato un modello analitico per determinare la pressione di perdita.
- Similitudine con la fessura parzialmente aperta,
Fattore di Intensificazione delle Tensioni NULLO.
- Validazione della posizione del fronte di apertura mediante modello **Elementi Finiti**.
- Validazione definitiva mediante prove di pressurizzazione in **piena scala** e in **scala ridotta**.
- Strumento di **progetto** della geometria della flangia.