Bologna 14 Ottobre 2004 - *SAIE*

AIPE
Associazione Italiana Polistirolo Espanso

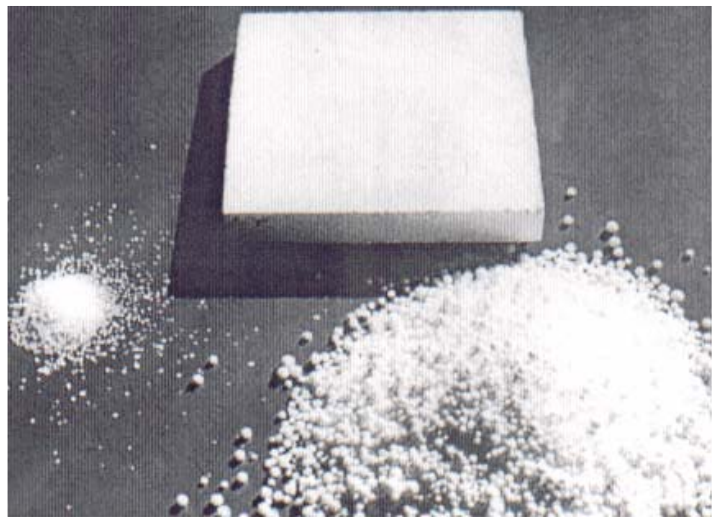
Leggero, resistente, isolante
costruire rilevati e fondazioni con EPS

RILEVATI STRADALI IN EPS
Requisiti meccanici e tecniche applicative

Prof. Ing. Antonio Montepara – Prof. Ing. Felice Giuliani

Dipartimento di Ingegneria Civile,
dell'Ambiente, del Territorio e Architettura
Università degli Studi di Parma

Il Polistirene Espanso Sinterizzato (EPS)



- **Materiale plastico derivato dal petrolio**
- **Processo di produzione: pre-espansione, maturazione, stampaggio**
- **Le principali caratteristiche: leggerezza, struttura rigida, tenacità, bassa conduttività termica, interamente riciclabile**
- **Normativa sull'EPS: la norma UNI 7819-1988**

COSTRUZIONI STRADALI ?

Problema 1.
Carenza di materiali idonei alle costruzioni stradali

Stabilizzazione (granulometrica o con leganti idraulici)

Riciclaggio (prodotti da demolizione pre-processati)

Materiali innovativi?

Problema 2.
Terreni a bassa portanza

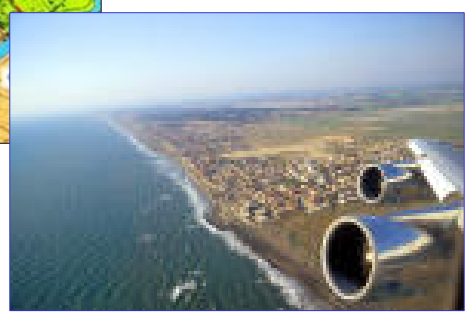
Bonifiche

Pre-consolidazione

Materiali Leggeri?

Bassa Padana

Fiumicino



Problema 3.
Vincoli geometrici, versanti instabili

Grandi rilevati (pendenze, espropri,)

Movimenti franosi

(frane profonde, superficiali e spondali)

Materiali ad elevata stabilità?

Problema 4.
Viabilità d'emergenza, Protezione Civile

Post-Emergenza

Viabilità di cantiere (piste temporanee, deviazioni di tracciato)

Materiali facilmente movimentabili e riutilizzabili?

Rilevati Stradali in EPS

- **Limitazione dei cedimenti per consolidazione del terreno di fondazione**
- **Riduzione del movimento terra**
- **Riduzione dell'area di ingombro del rilevato**
- **Cantieri – Viabilità di emergenza – Movimenti franosi**

Convenzione di Studio

UNIVERSITÀ DI PARMA

AIPE ASSOCIAZIONE ITALIANA POLISTIROLO ESPANSO

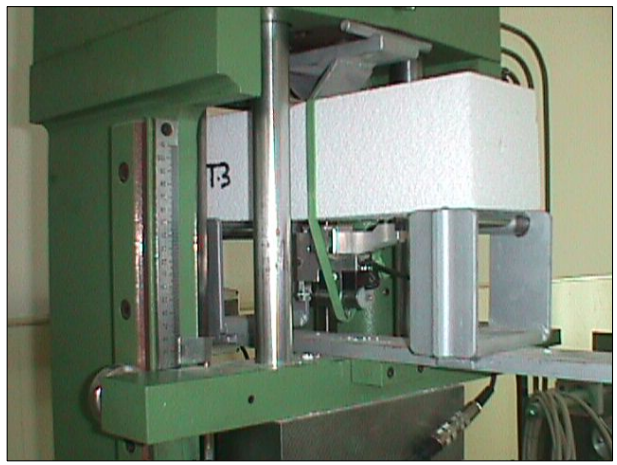
Studio sperimentale per la costuzione di rilevati alleggeriti con polistirolo su terreni a bassa portanza

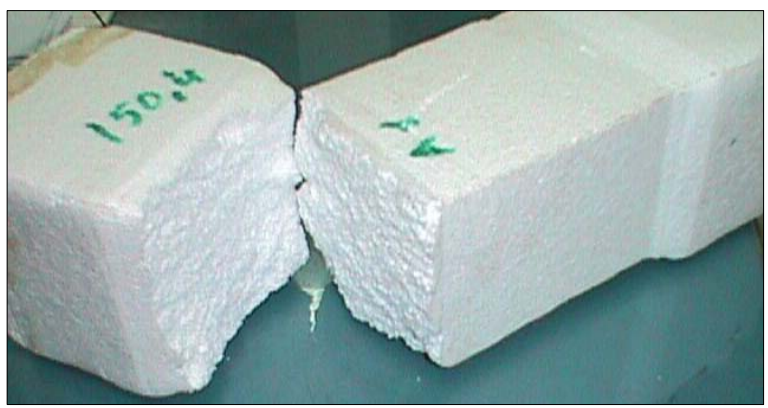
- Caratterizzazione meccanica di laboratorio
- Studio e progettazione di un rilevato sperimentale
- Monitoraggio in sito – studio dei fenomeni di creep

Proprietà Fisiche principali

Caratterizzazione Chimica (EPS autoestinguente)

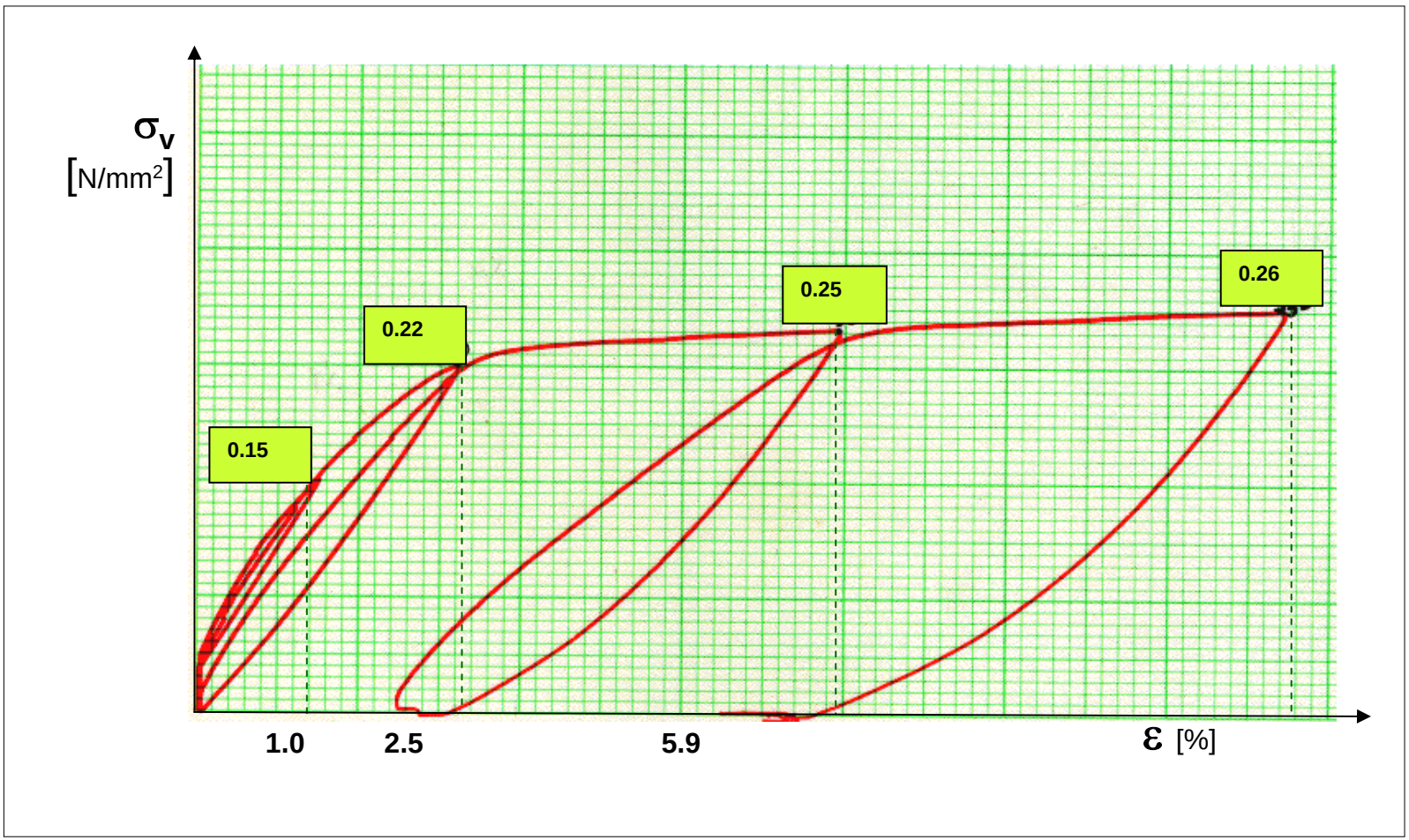
Caratterizzazione Meccanica



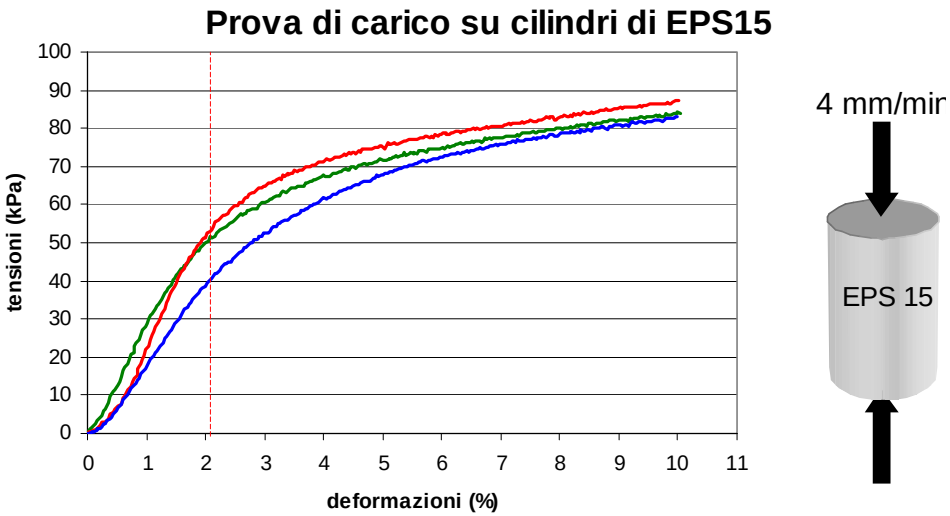


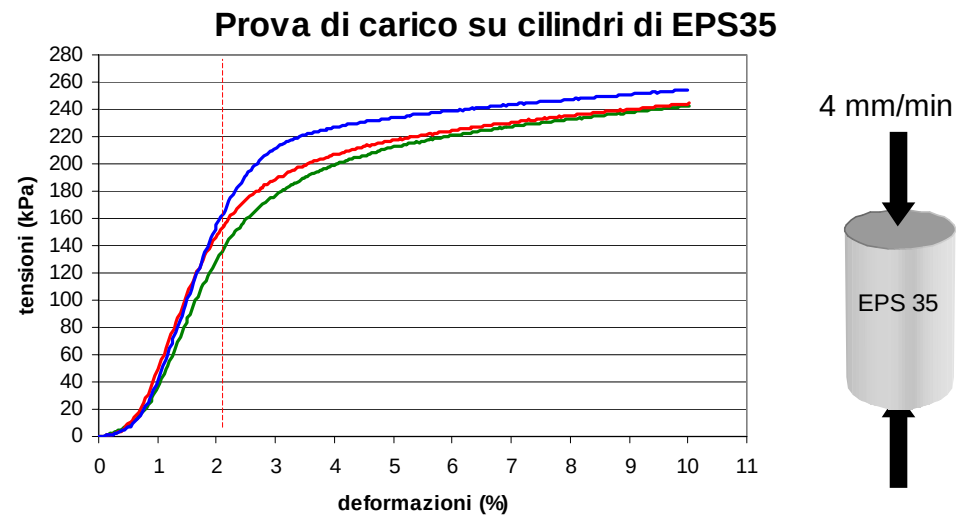
Resistenza a compressione e legame costitutivo

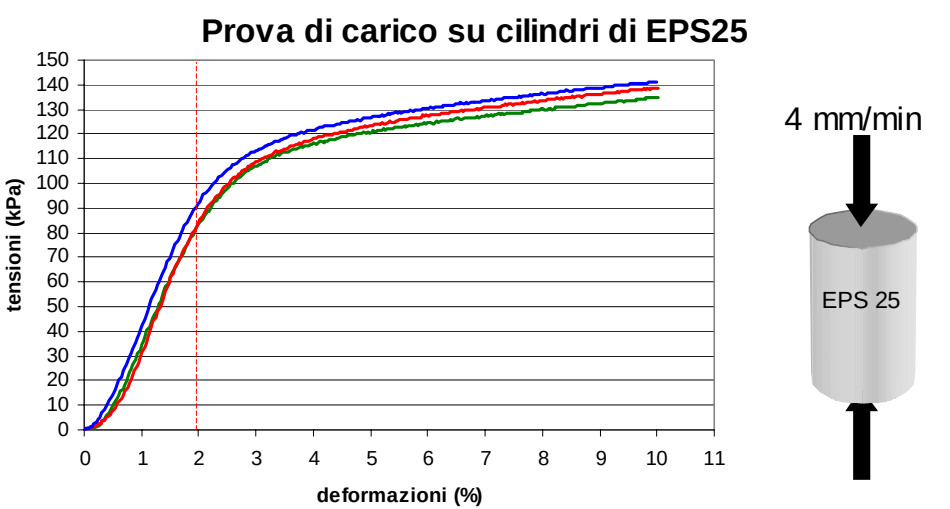
Densità	[Kg/m^3]	15	20	30	34	38	41	43
σ_c (ε = 1%)	[N/mm^2]	0.04	0.05	0.10	0.13	0.13	0.16	0.16
σ_c (ε = 10%)	[N/mm^2]	--	--	0.21	0.26	0.29	0.33	0.33

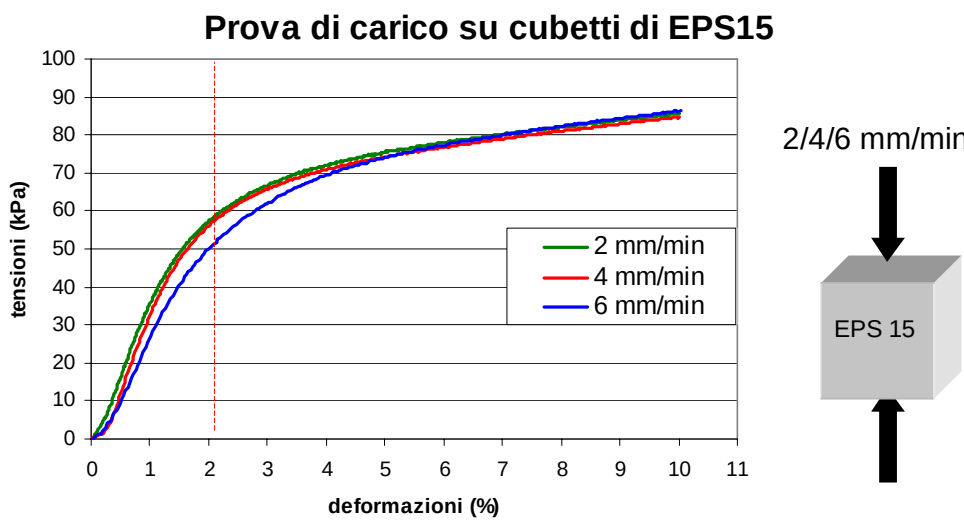


Resistenza a compressione e legame costitutivo









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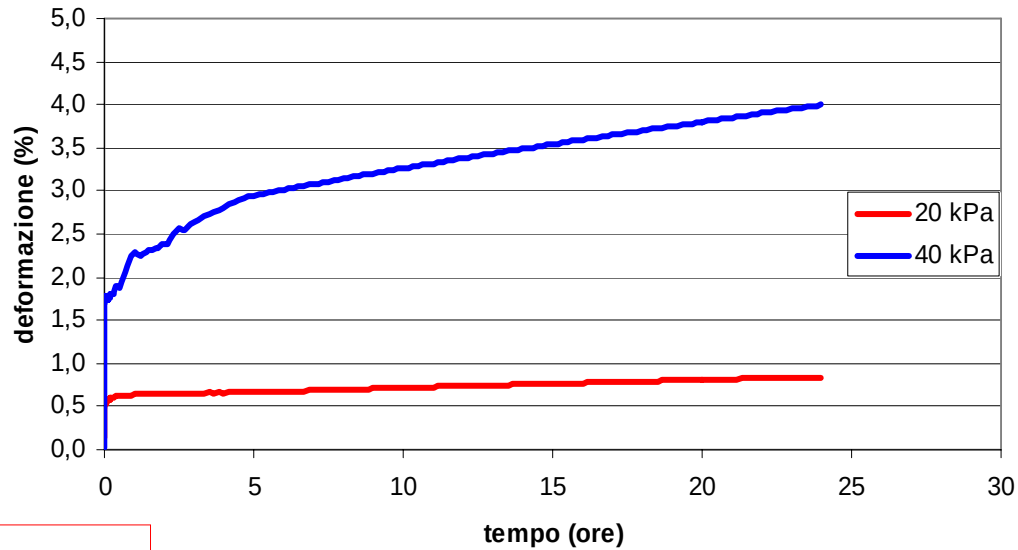
Prove di Creep Statico

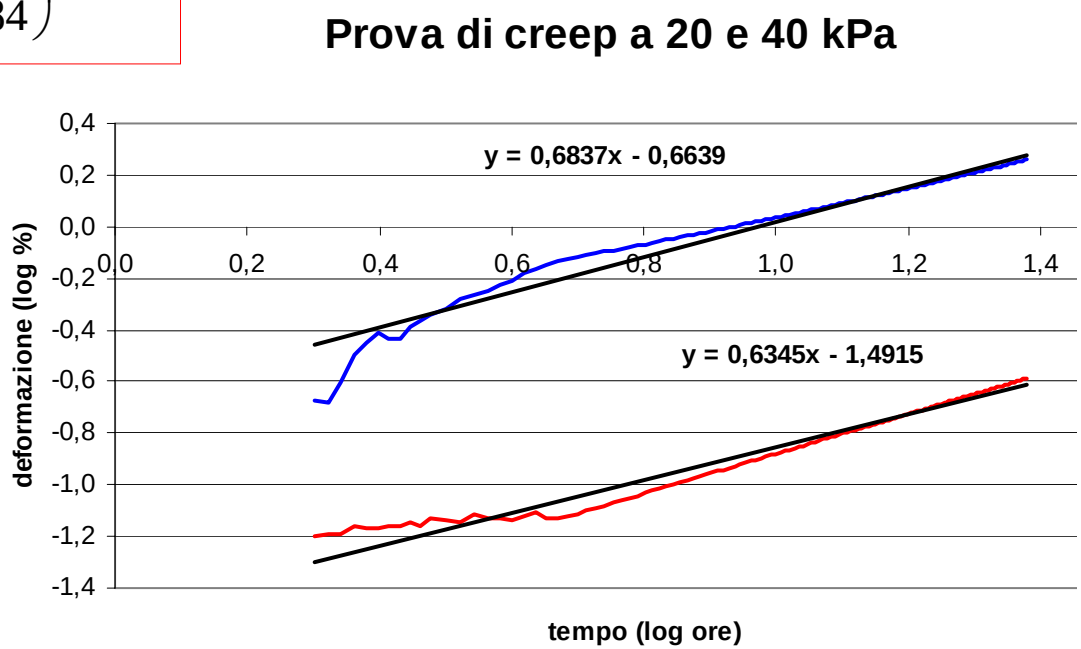
EPS 15



$$\varepsilon = 0{,}0016 \cdot sinh\left(\frac{\sigma}{16{,}23}\right) + 0{,}0037 \cdot sinh\left(\frac{\sigma}{66{,}84}\right) \cdot t^{0{,}66}$$

Findley Equation

Horvarth (1998)



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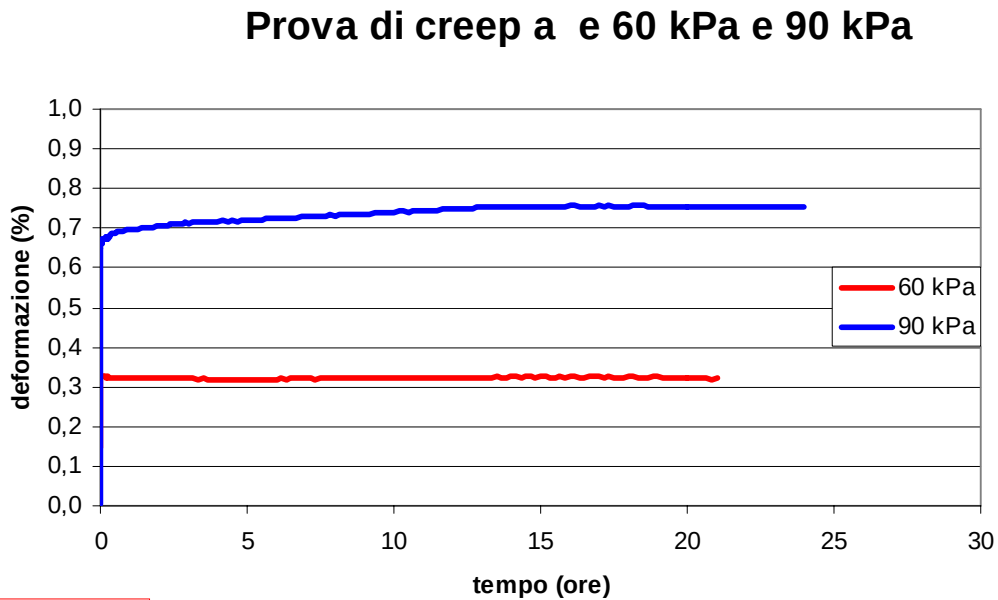
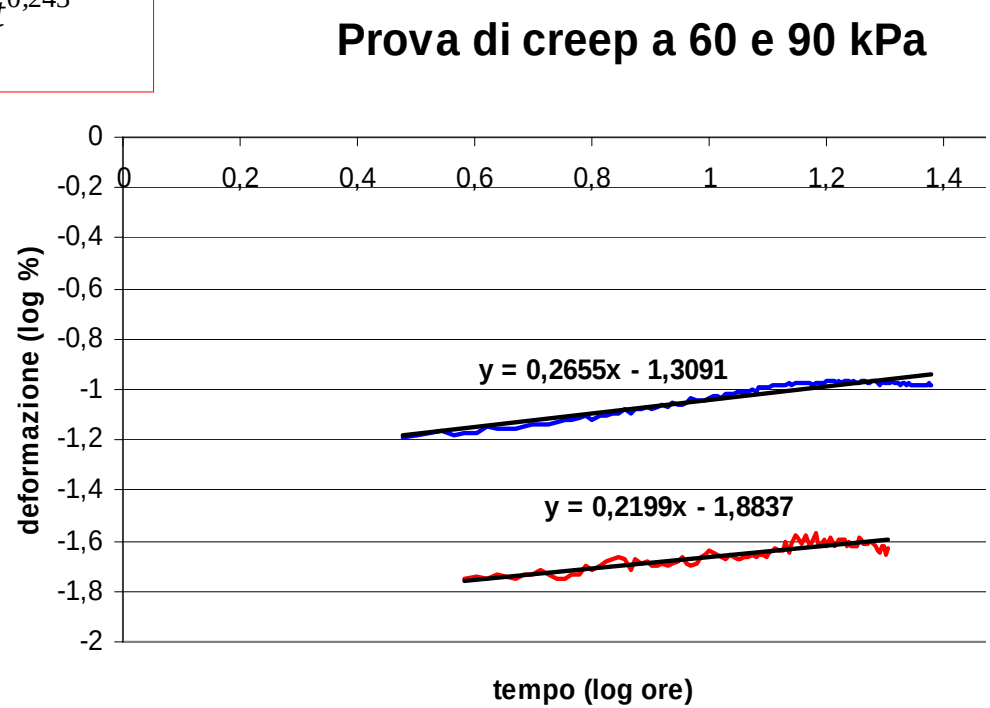
Prove di Creep Statico

EPS 35



$$\varepsilon = 0{,}0015 \cdot sinh\left(\frac{\sigma}{41{,}28}\right) + 0{,}0001 \cdot sinh\left(\frac{\sigma}{40{,}82}\right) \cdot t^{0{,}243}$$



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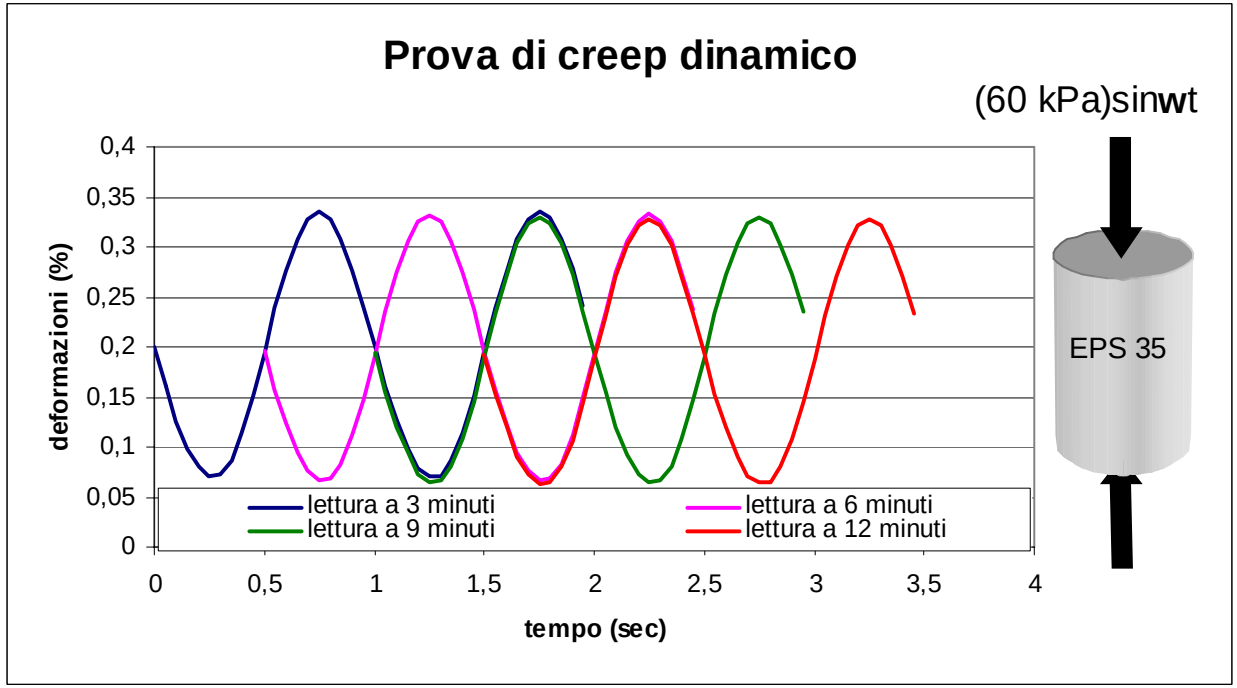
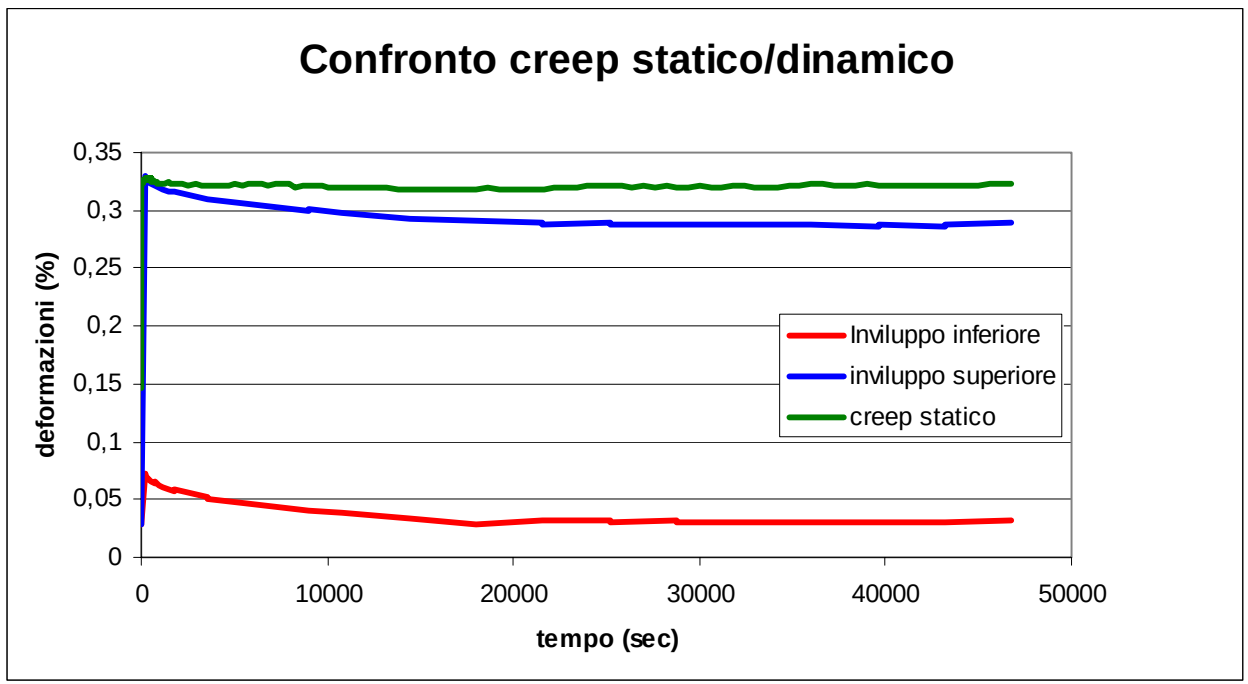
Prove di Creep Dinamico

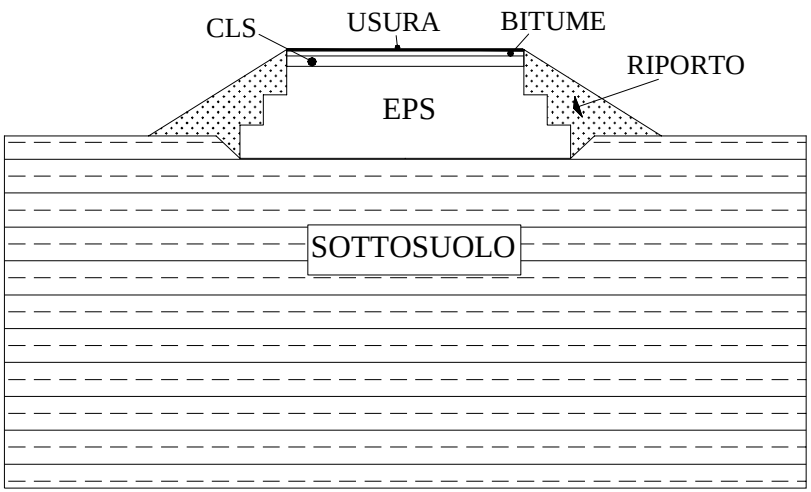
EPS 35

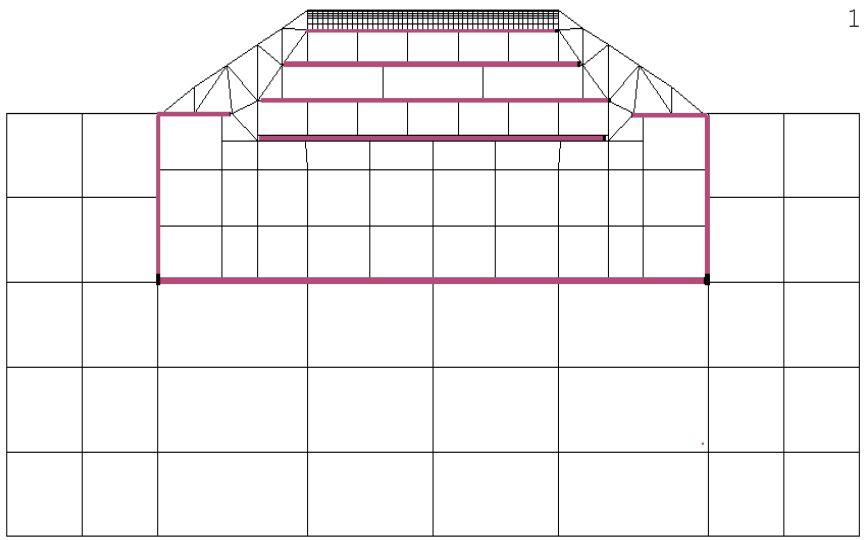




Analisi FEM per lo studio del corpo stradale e delle pavimentazioni

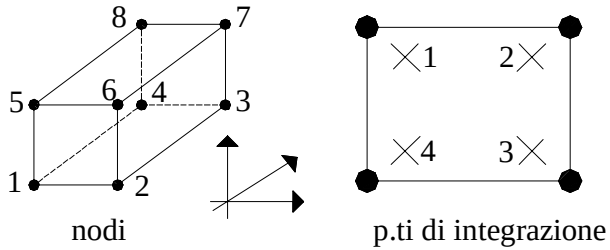
ABAQUS/Standard -> visco-plasticità del materiale, carichi dinamici, effetti distorsioni termiche

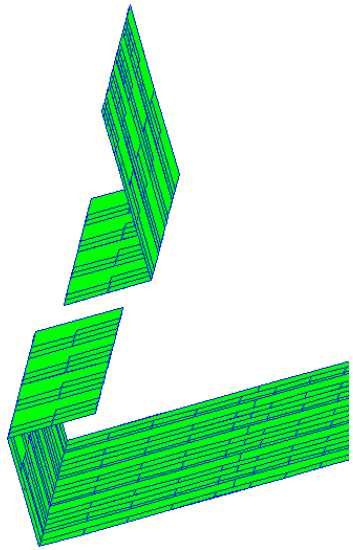




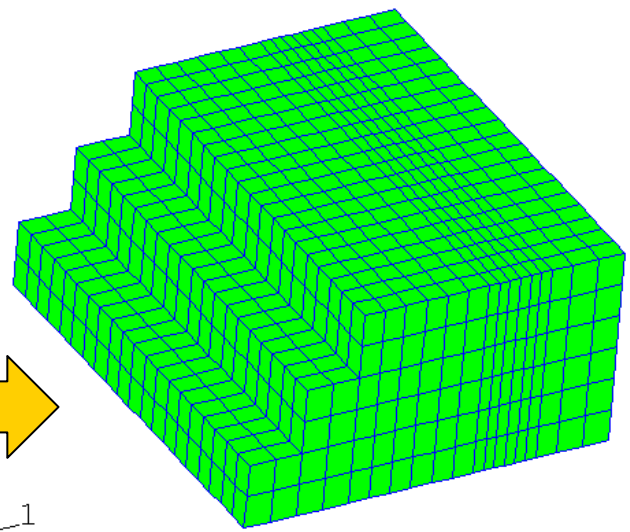
Abaqus Standard

elemento 8 nodi





- **Preprocessing -> Simulazione -> postprocessing**
- **Carattere simmetrico del problema**
- **Infittimento della mesh nella zona del carico**
- **EPS solido continuo / in blocchi**



Scelta della sovrastruttura

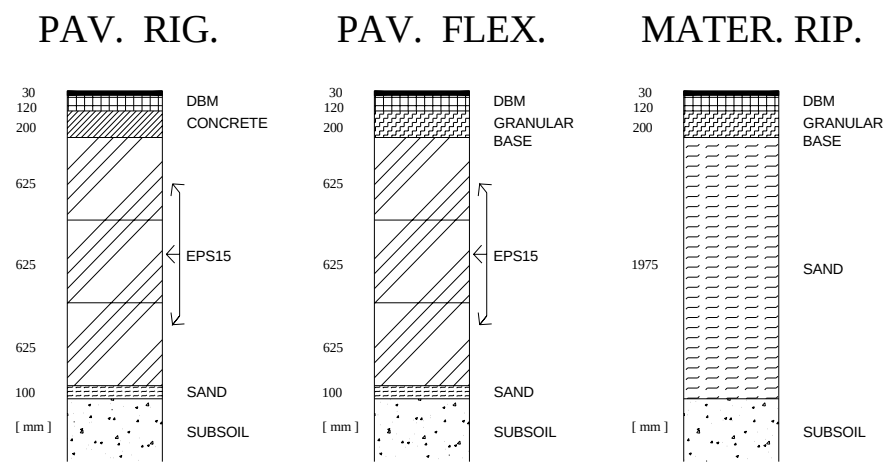
19 Casi Studiati :

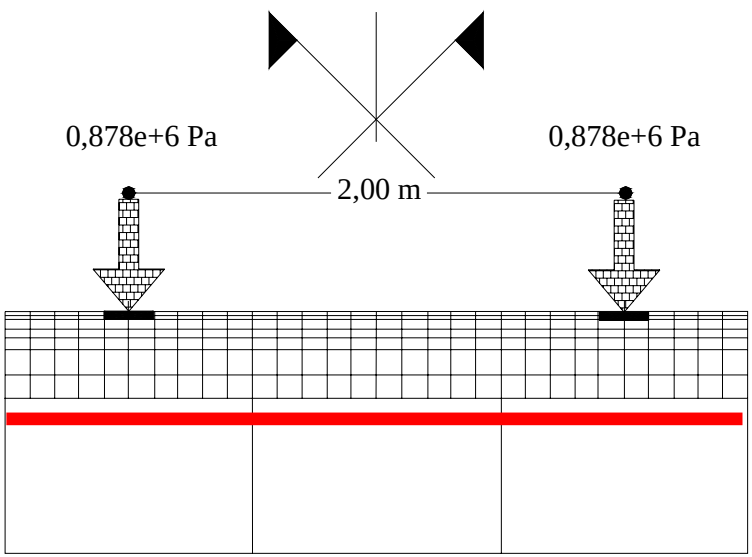
- Materiali
- Comportamento meccanico

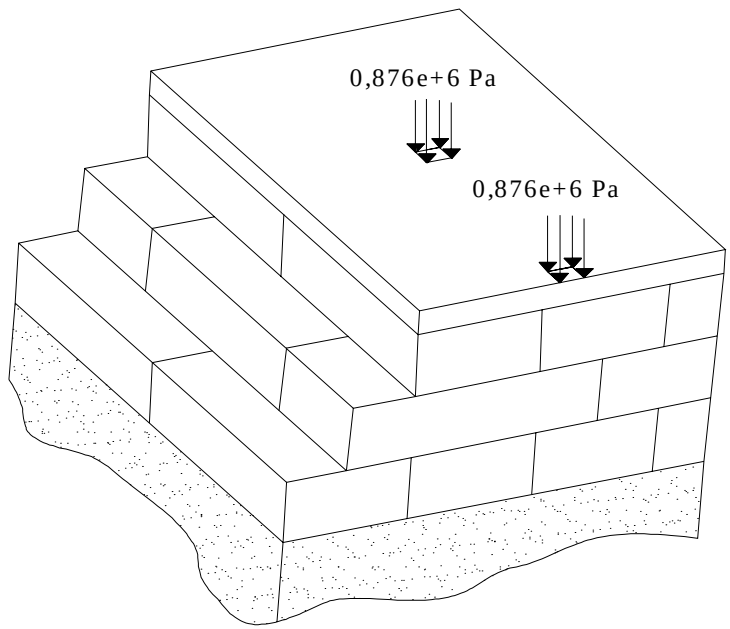
(legge di creep propria del'EPS)

- Modalità e posizione del carico
- Tipo di analisi (statica, dinamica)

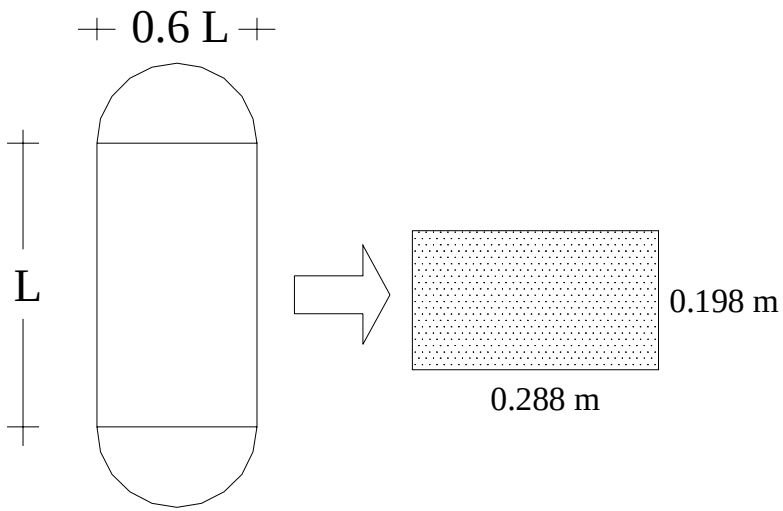
2-D L.E. , 2-D N.L.E. ,3-D L.E.







Definizione della superficie di carico



- **Carico d'asse di 10 t**
- **Impronta ellittica**

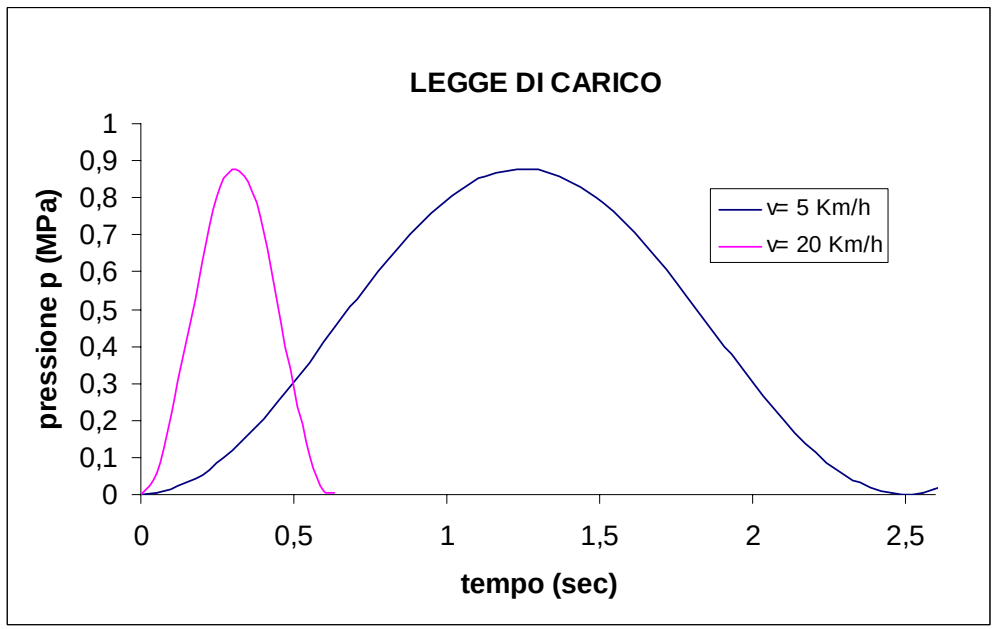
area rettangolare

- **Carico di tipo**

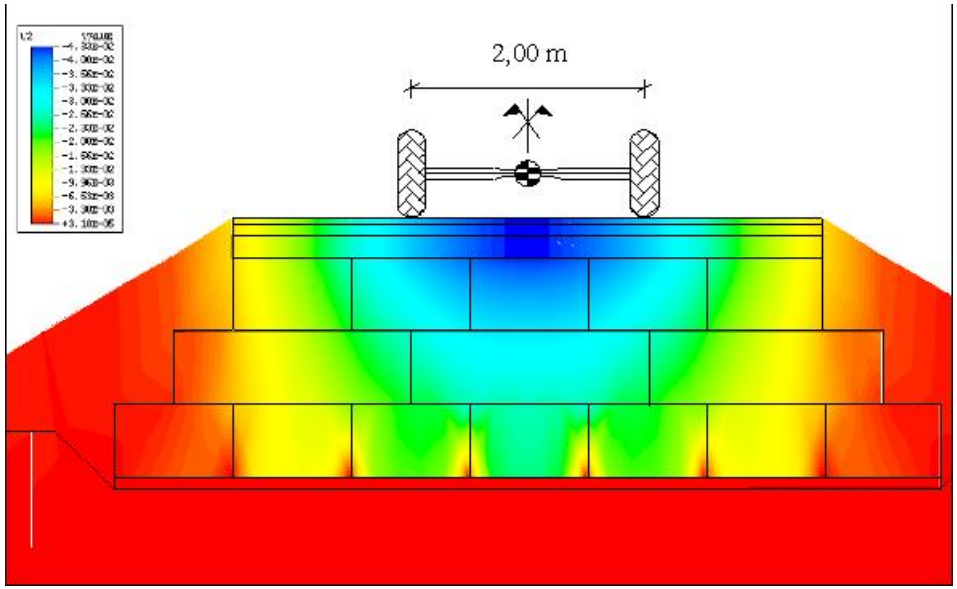
  -) statico

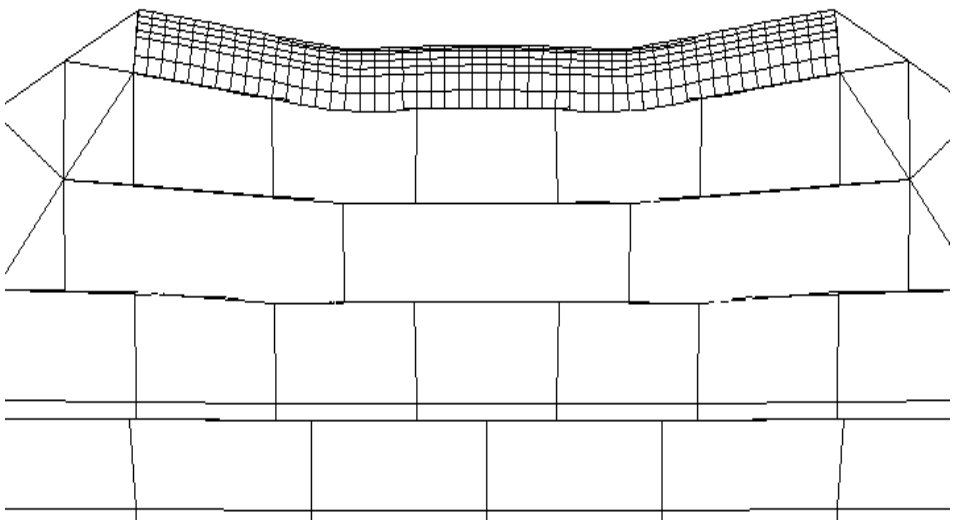
  -) dinamico

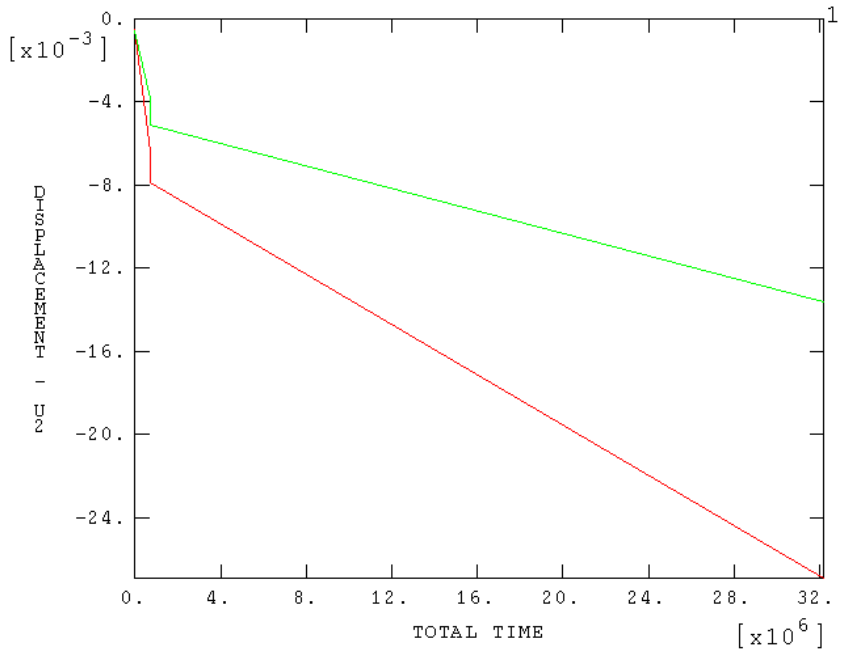
$$p(t) = p_0\left[0.5 - 0.5\cos\left(\frac{2\cdot\pi\cdot t}{T_0}\right)\right]$$



Studio 2-D Materiale Visco-Plastico



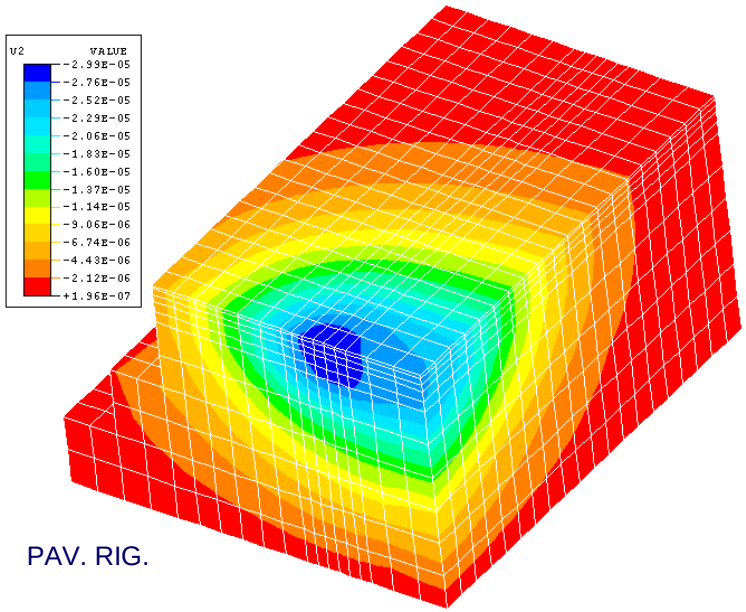




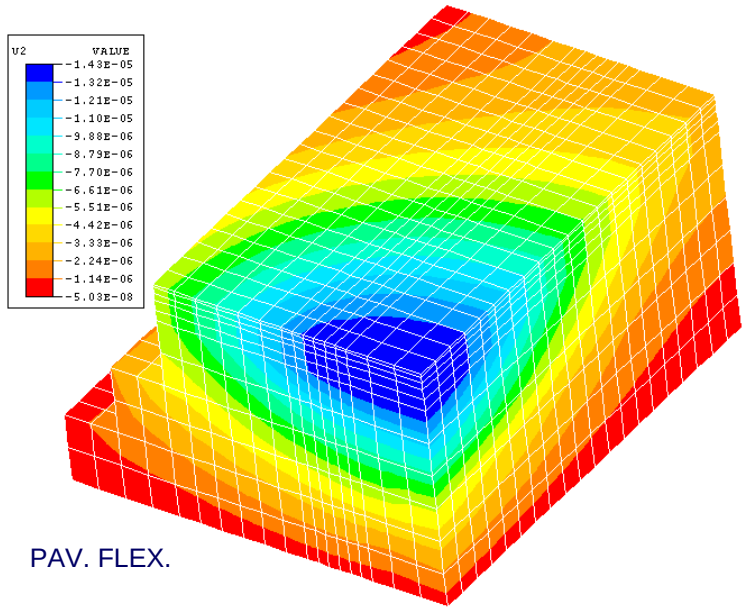
PAV. RIG.

PAV. FLEX.

Studio 3-D Materiale Elastico-Lineare



PAV. RIG.



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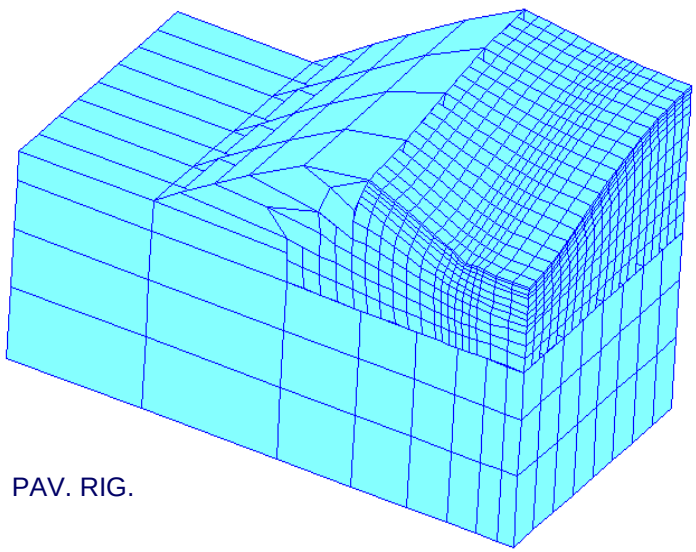

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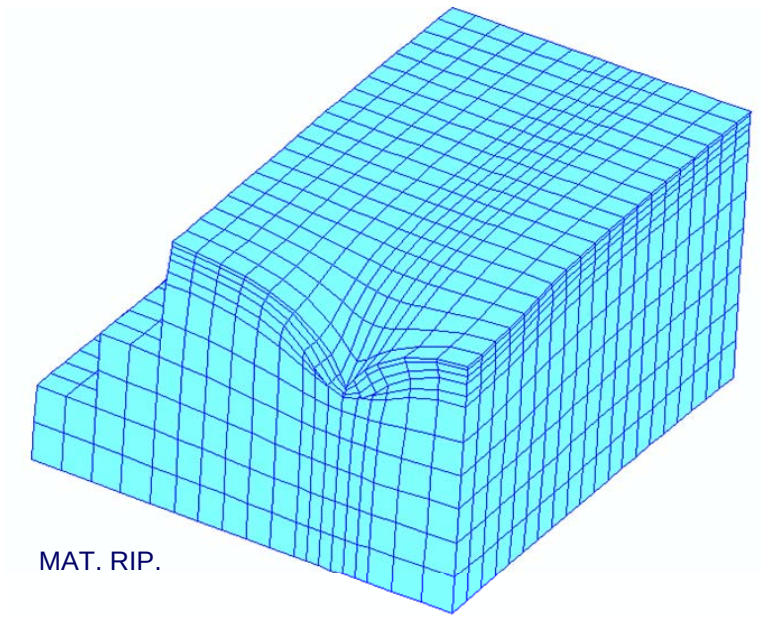
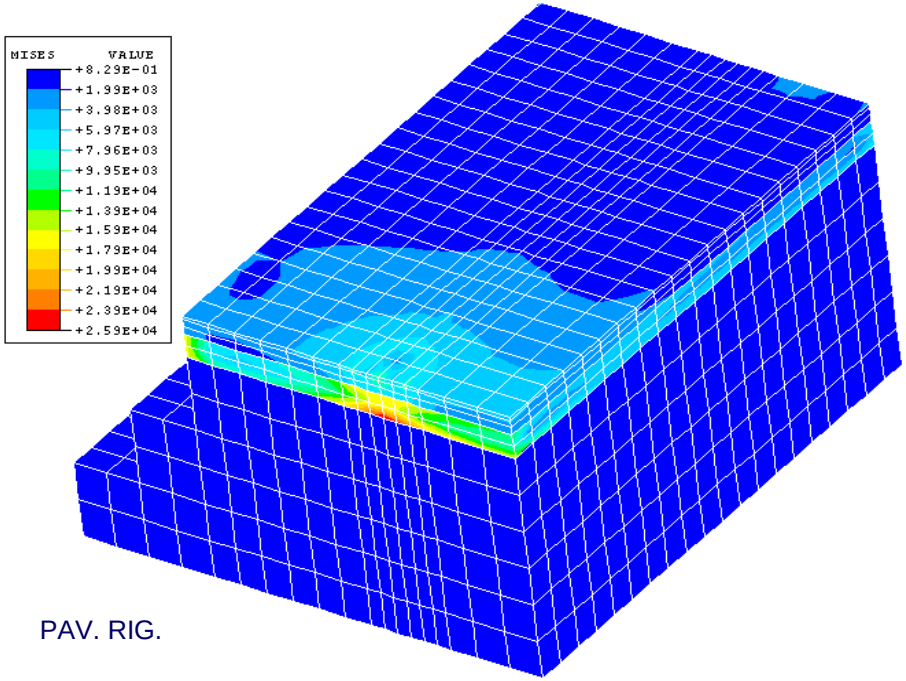


MAT. RIP.



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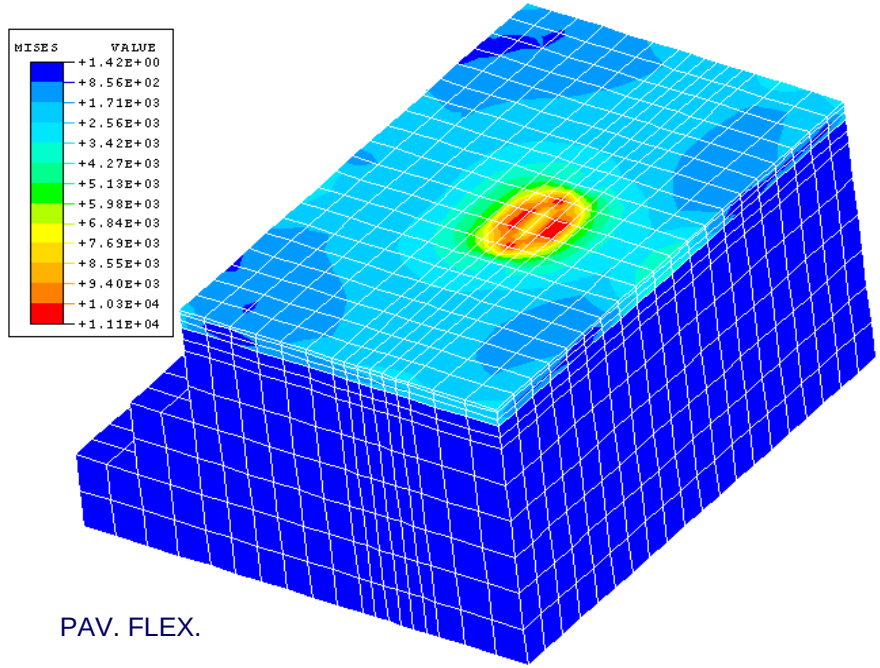
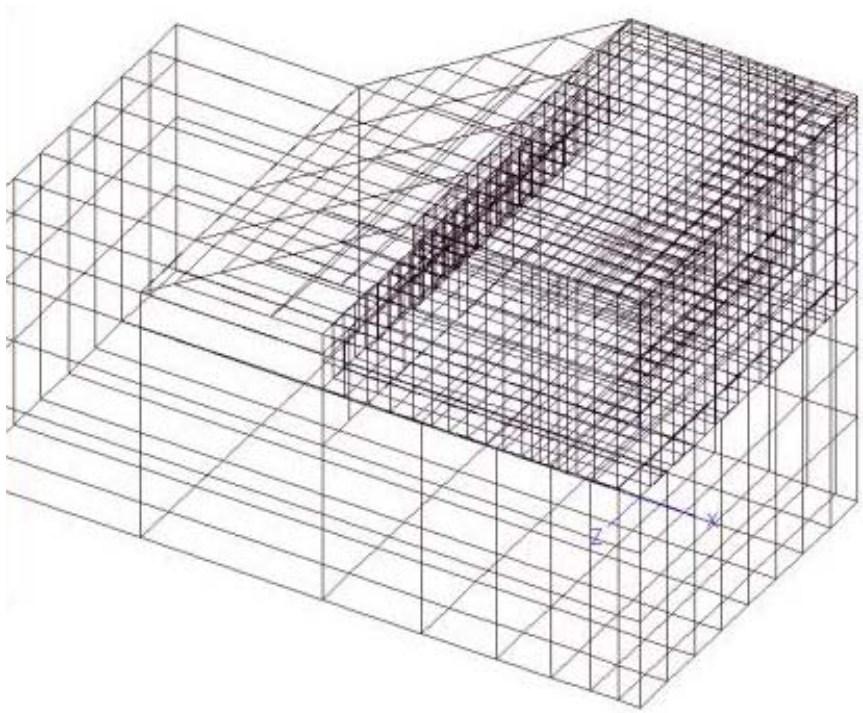


PAV. FLEX.



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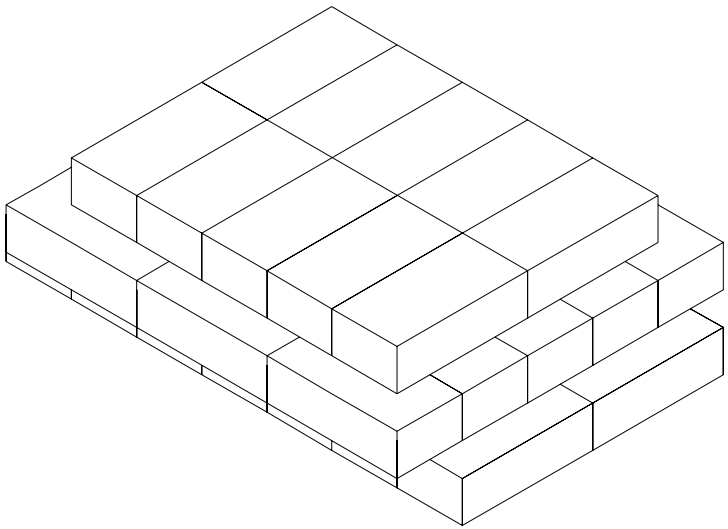
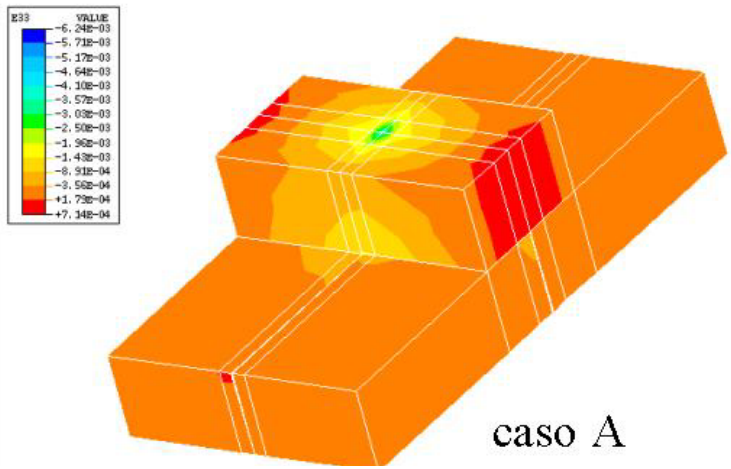
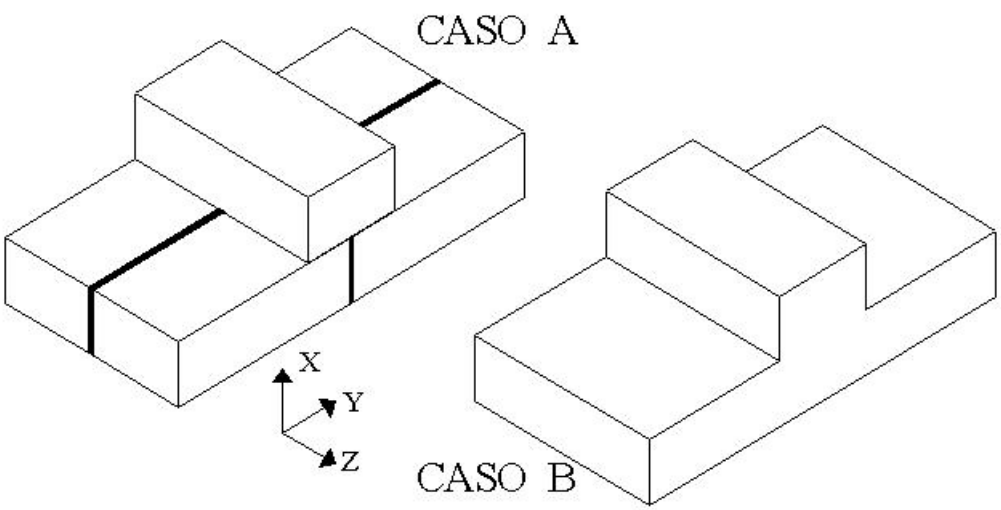
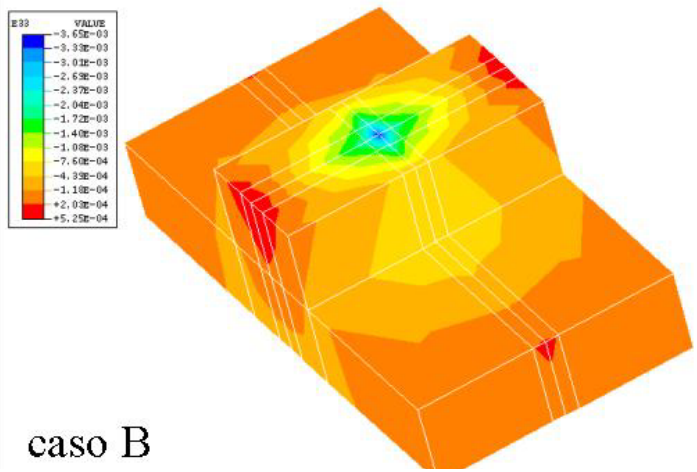
Disposizione dei blocchi di EPS

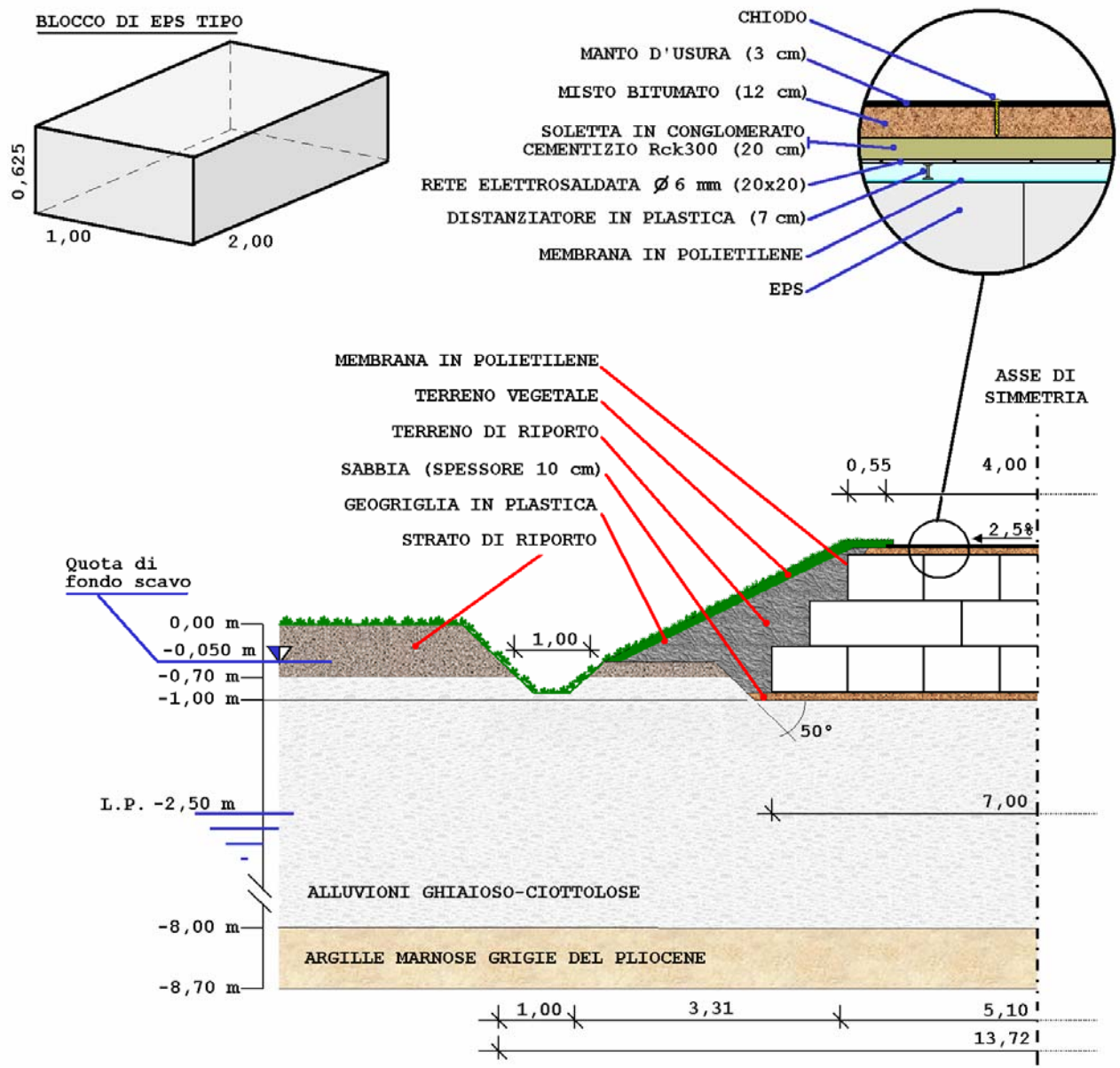








Rilevato Sperimentale



Rilevato Sperimentale

Preparazione dei blocchi (15-25-35 kg/m^3)

EPS 15

valore	media	varianza	s.q.m.
l_1	1,998	1,07E-06	0,001033
l_2	0,998	1,02E-06	0,001008
l_3	0,626	4,97E-06	0,002229

EPS 25

valore	media	varianza	s.q.m
l_1	1,998	1,27E-06	0,001129
l_2	0,999	5,47E-07	0,000739
l_3	0,626	4,02E-06	0,002006

EPS 35

valore	media	varianza	s.q.m
l_1	1,998	1,34E-06	0,001157
l_2	0,998	7,92E-07	0,000890
l_3	0,627	4,32E-06	0,002078

Controllo della geometria

Rilevato Sperimentale

Preparazione dei blocchi (15-25-35 kg/m^3)

densità	media	varianza	s.q.m
EPS15	**14,87**	**0,015**	**0,122**
EPS25	**23,88**	**0,070**	**0,265**
EPS35	**33,98**	**0,309**	**0,556**

Controllo della densità

Rilevato Sperimentale

Scelta del sito

POLISETTE S.r.l.
Sala Baganza (PR)

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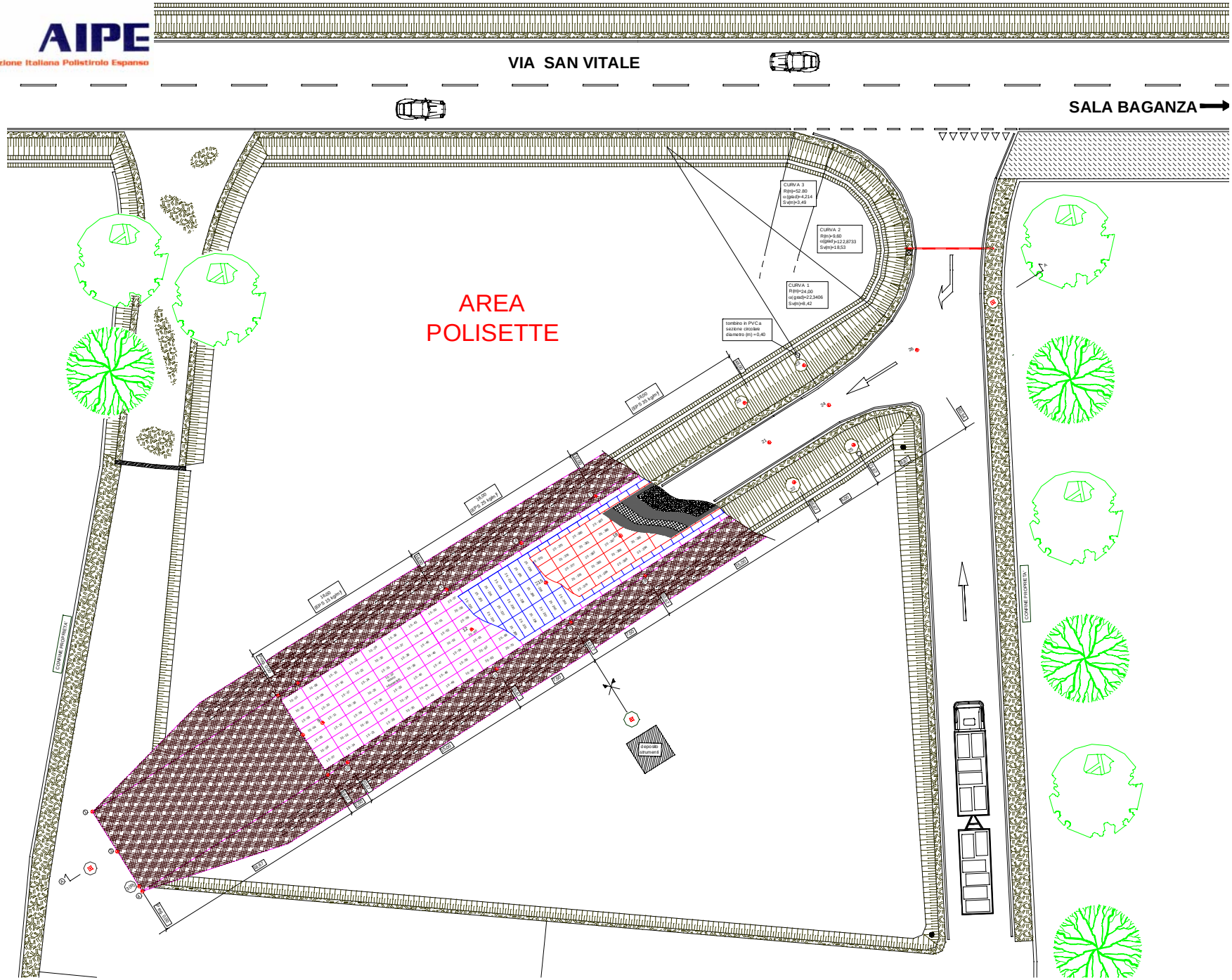
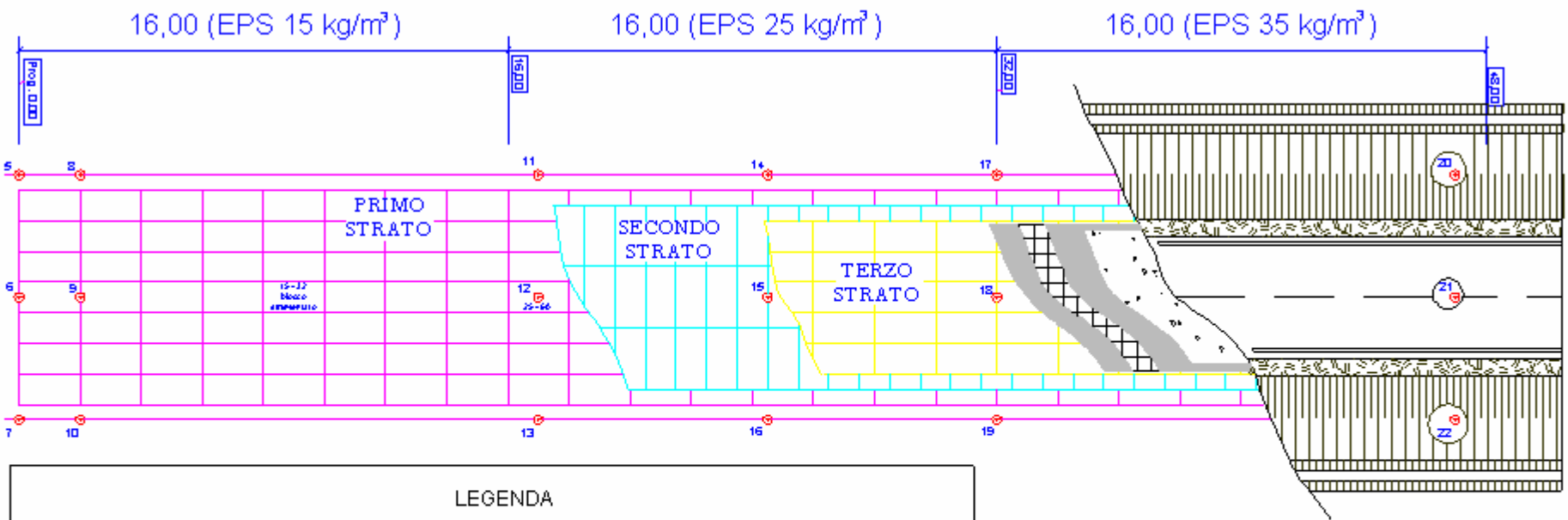


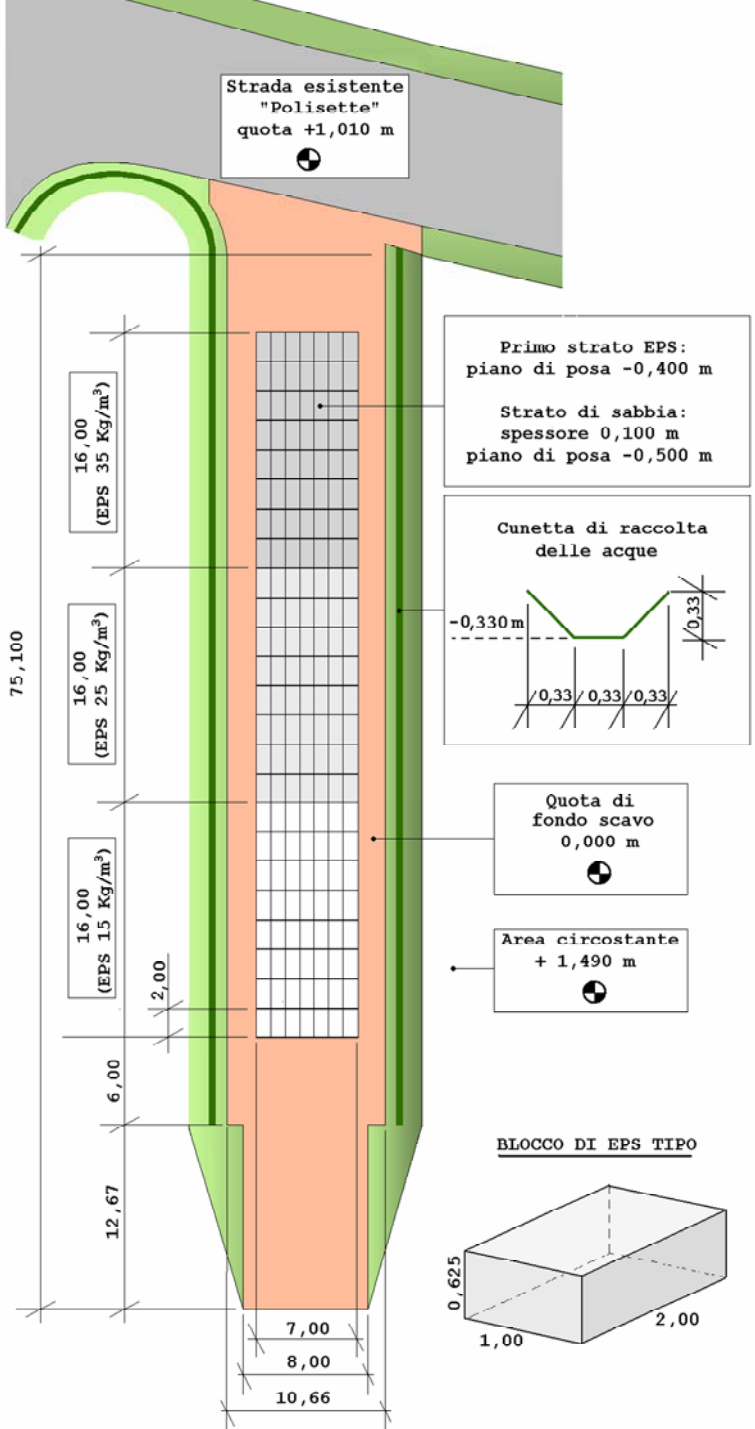
Rilevato Sperimentale

Allestimento del tratto sperimentale “Polisette”



LEGENDA			
SIMBOLOGIA	DESCRIZIONE	SIMBOLOGIA	DESCRIZIONE
	picchetto		soletta in conglomerato cementizio (Rck 300) spessore 20 cm rete elettrosaldata (ϕ= 6 mm, 20 x 20)
	blocchi in EPS densità (kg/m³) - numero blocco		misto bitumato (spessore 12 cm)

Rilevato Sperimentale



Rilevato Sperimentale “Polisette”

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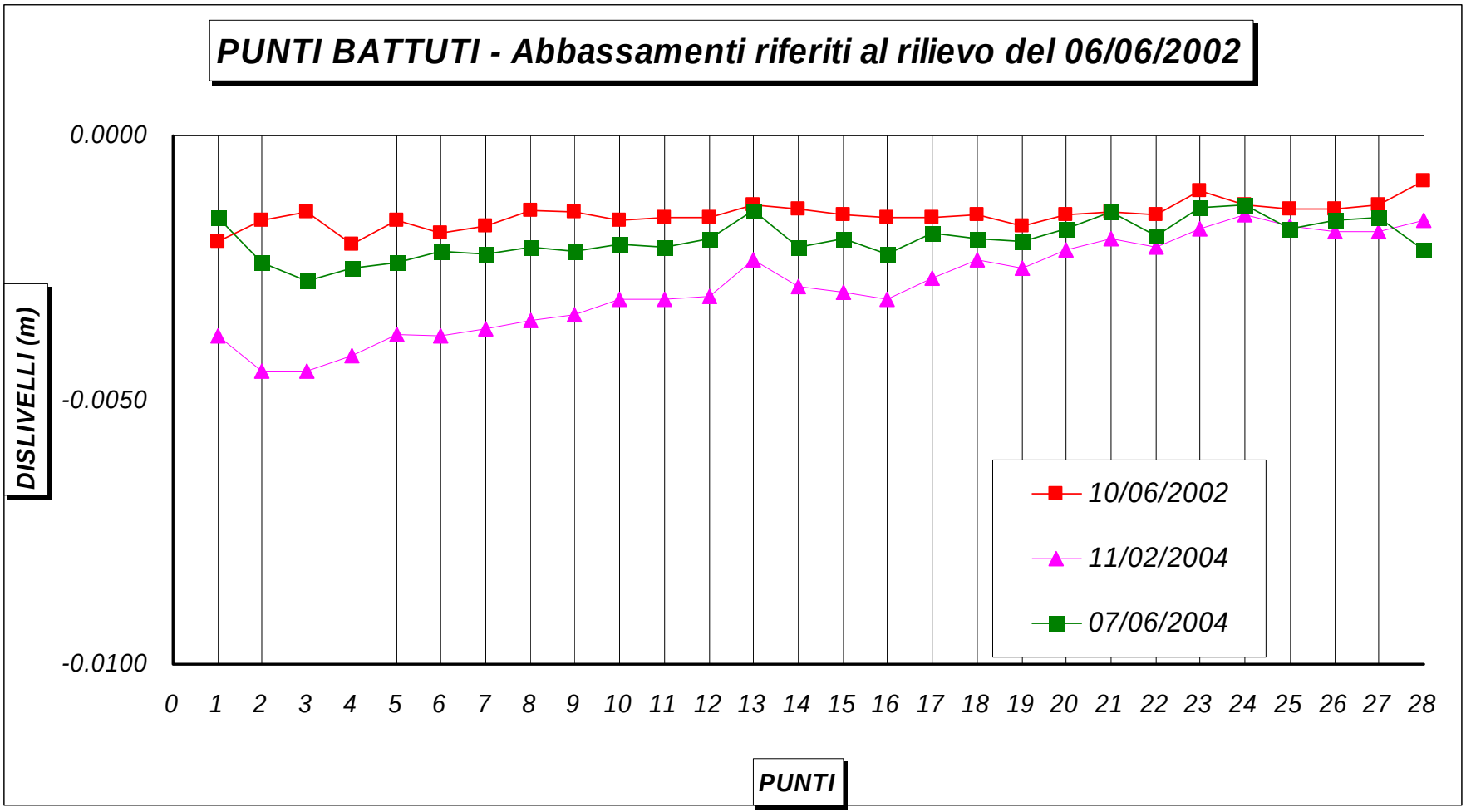
Rilevato Sperimentale

Monitoraggio dei cedimenti



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Conclusioni

- Condizioni di Impiego dell'EPS nei Rilevati Stradali

- Criteri base per il corretto dimensionamento

- Impieghi per opere permanenti e temporanee

Bologna 14 Ottobre 2004 - *SAIE*

Leggero, resistente, isolante

costruire rilevati e fondazioni con EPS

RILEVATI STRADALI IN EPS
Requisiti meccanici e tecniche applicative

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