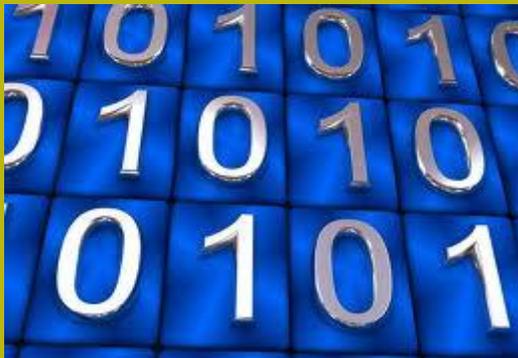




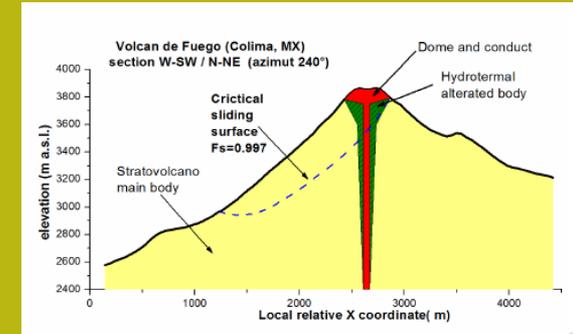
Evaluación de la estabilidad de taludes complejos en suelo y roca por medio de software SSAP-2010: aplicaciones en Italia y México



Dr. *Lorenzo Borselli*
 Instituto de Geología
 Fac. De Ingeniería, UASLP



lborselli@gmail.com
www.lorenzo-borselli.eu



SSAP 2010 (versione 4.2.0 - 2012)

SLOPE STABILITY ANALYSIS PROGRAM
 release 4.2.0 (c) (1991-2012)
 Build No. 5945
 by Dr. Geol. Lorenzo Borselli, Ph.D.
 lorenzo.borselli@cnr.it
<http://www.lorenzo-borselli.eu>

AVVIO VERIFICA
 VERIFICA GLOBALE
 VERIFICA SINGOLA

RISULTATI
 DIAGRAMMI FORZE
 GENERA / VEDI MAPPA F_s LOCALE
 VEDI GRAFICI SUPERFICI

MONITOR VERIFICA
 MODELLO PENDIO: **ESS.MOD**

MODELLO DI CALCOLO
 MODELLO DI CALCOLO: Morgenstern e Price (1965)
 COEFFICIENTI SIMICI: ORIZZONTALE (K_h): 0.0000
 VERTICALE (K_v): 0.0000

PARAMETRI ATTIVI PER GENERAZIONE SUPERFICI
 MOTORE DI RICERCA SUPERFICI: Convex Random Search (CRS)
 ZONA DI INIZIO - Progressiva - (m): da 0.00 a 100.00
 ZONA DI TERMINAZIONE - Progressiva - (m): da 12.00 a 117.00
 QUOTA LIMITE INFERIORE (m): 0.00
 LUNGHEZZA MEDIA SEGMENTI - (m): 4.00
 SMUSSA SUPERFICI: **Disattivato** EFFETTO TENSION CRACKS: **Attivato**
 RICERCA CON ATTRATTORE DINAMICO: **Attivato** METODO (bambini@F40): **A**

RISULTATI IN TEMPO REALE
 F_s ITERATIVO: 2.437
 RANGE F_s 10 SUPERFICI CON MINOR F_s: 1.440 - 1.521
 n. SUPERFICI GENERATE e VERIFICATE: 303 di 100000
 % EFFICIENZA GENERAZIONE SUPERFICI e % STABILITA' NUMERICA: 21.24 - 81.33

PERCENTUALE SUPERFICI COMPLETATE: 3.03 %

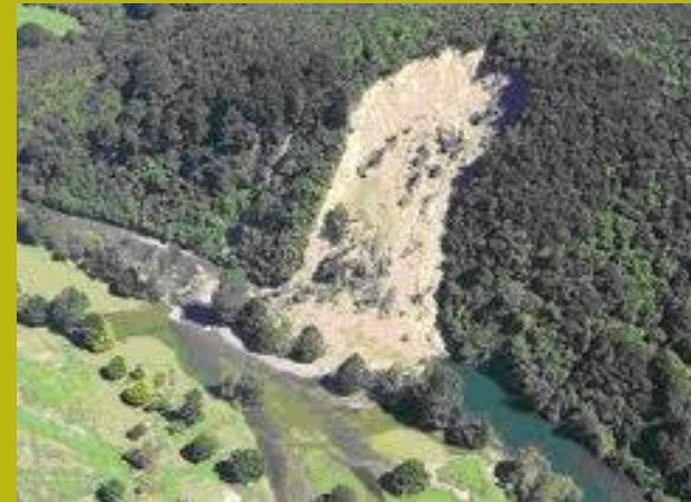
Premi ESC per Terminare - Premi INVIO/ENTER per stop temporaneo

SETUP VERIFICA
 INFO
 OPZIONI
 PARAMETRI
 GESTIONE ACQUIFERI
 OPZIONI AGGIUNTIVE

STRUMENTI
 GENERA REPORT VERIFICA
 GENERA FILES DXF
 ESPORTA SUPERFICI
 CAMBIA PAR. GEOTECNICI
 EDITA FILES
 MAKEFILES 3.2
 File SSAP2010.INI

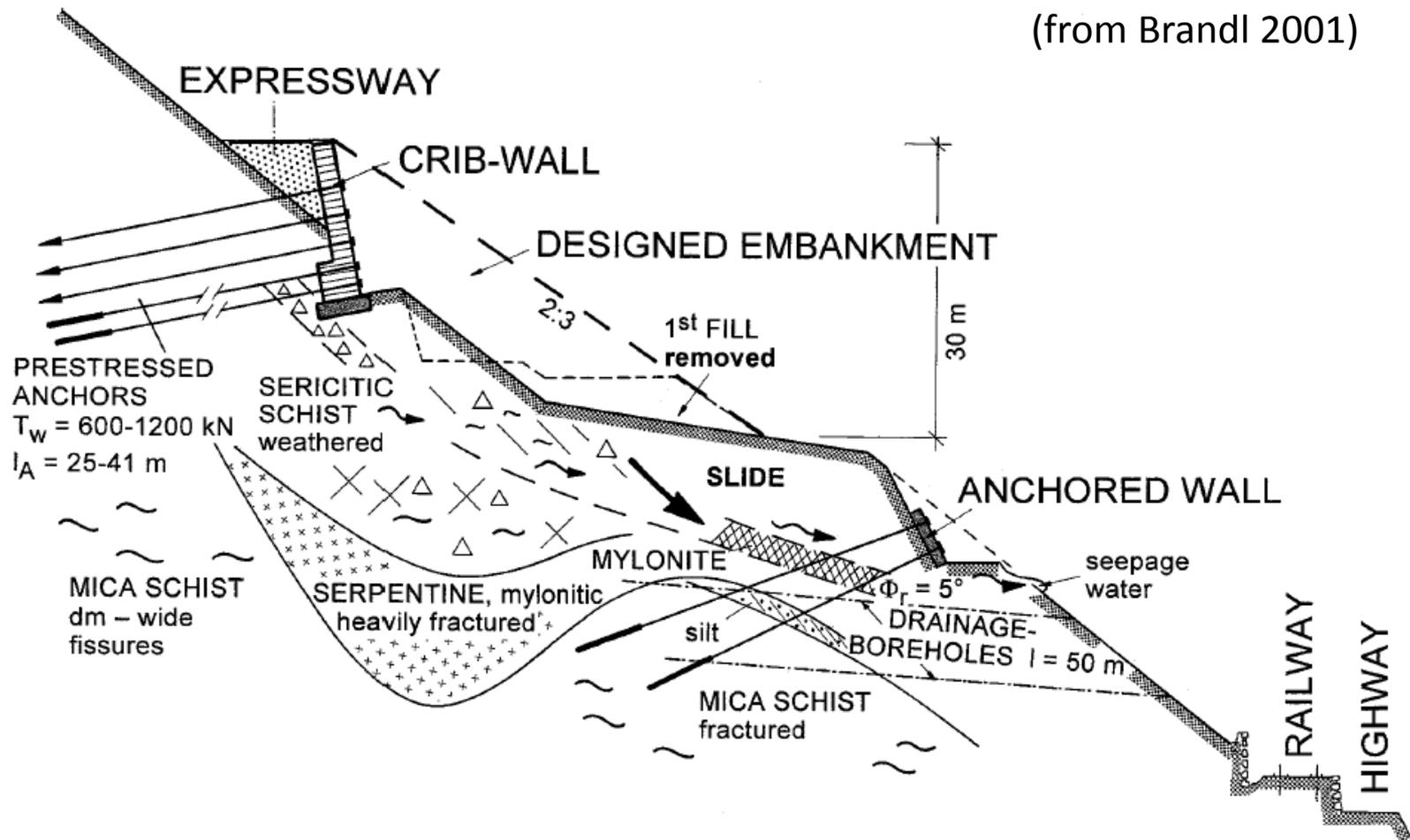
MESSAGGI
 SUGGERIMENTI: effettuata una verifica di stabilità è possibile generare un rapporto (file di testo) con tutti i risultati e anche una serie di file DXF con i grafici e esportare un file con le coordinate della superficie critica.

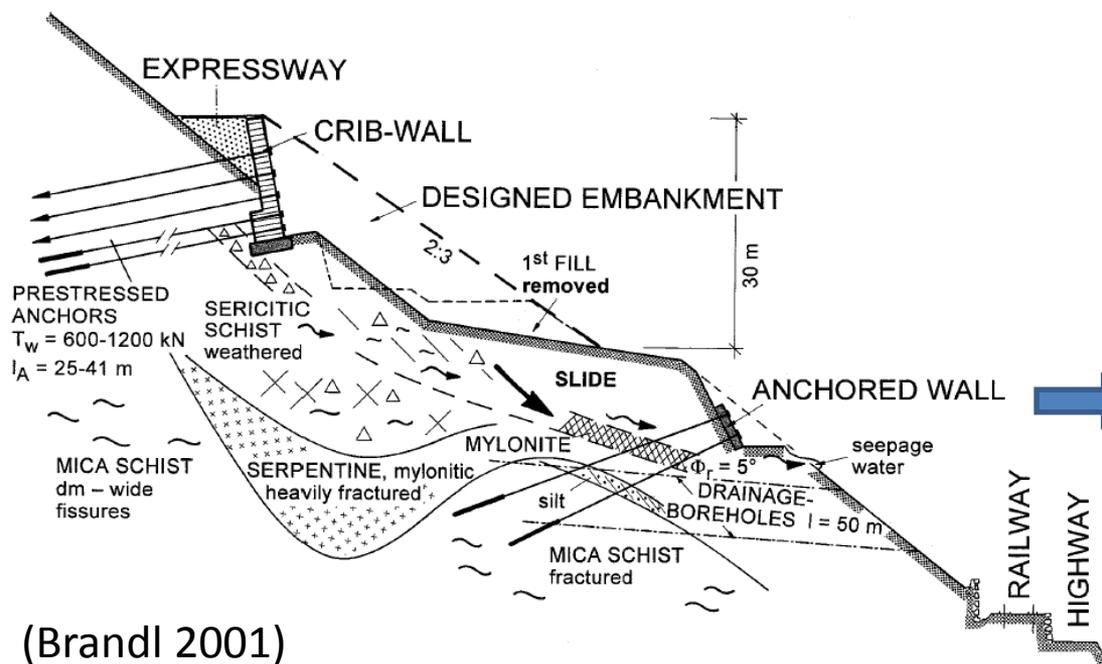
<http://WWW.SSAP.EU>



A pesar que la evaluación del nivel de estabilidad de un talud es una operación muy común como aplicación geotecnia, las mayores dificultades en averiguar el nivel de estabilidad de un talud puede ser resumidas en la modelación y el manejo del elevado potencial de complejidad interna...

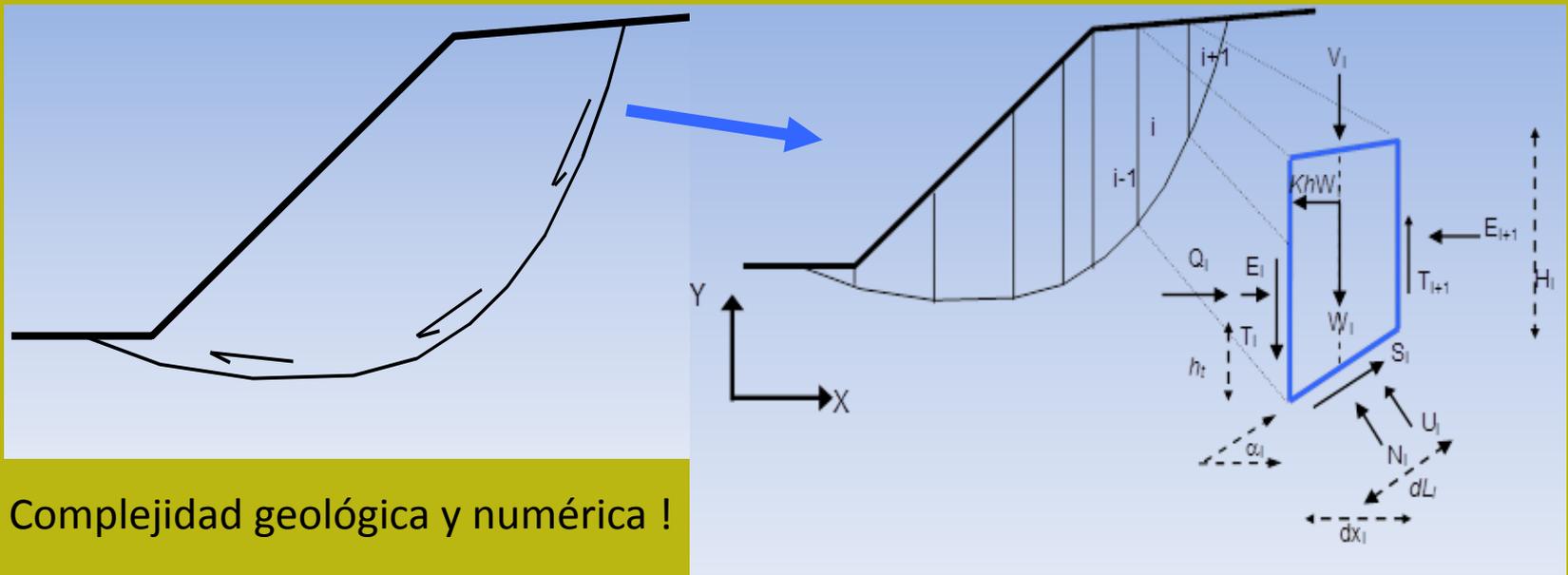
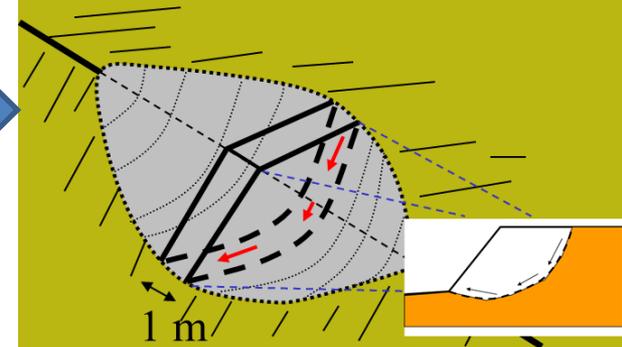
(from Brandl 2001)





(Brandl 2001)

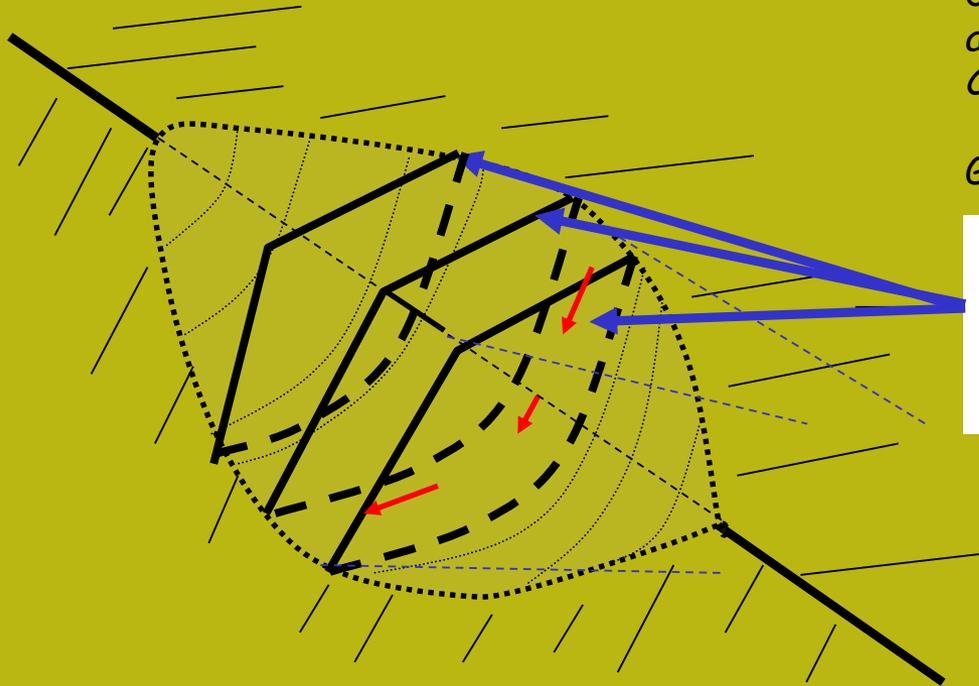
Análisis de estabilidad by LEM



Complejidad geológica y numérica !

Complejidad geométrica

Verifica de estabilidad 3D→2D



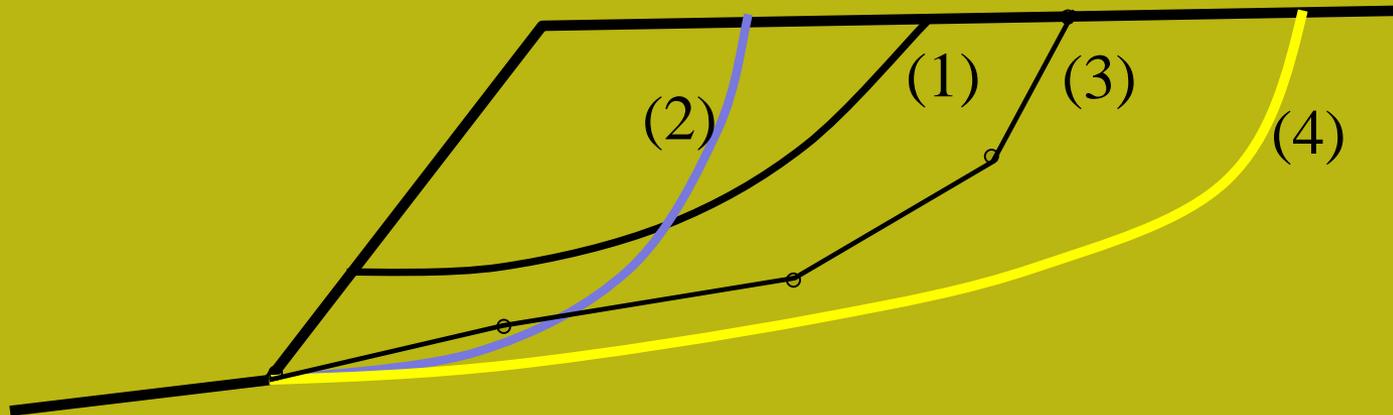
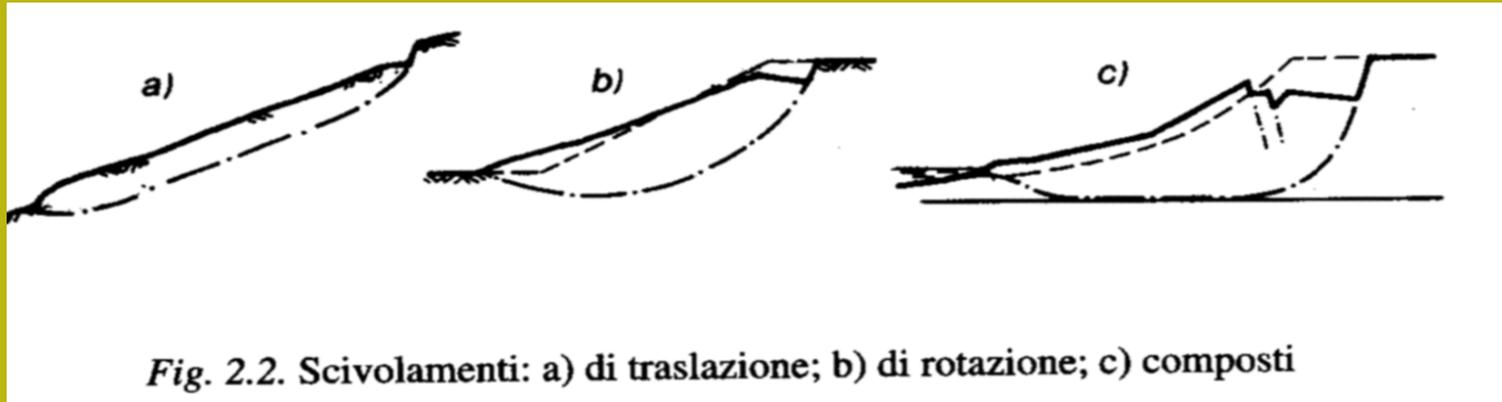
Naturalmente por medio del
cálculo de Fs de diversas
secciones 2D

Es posible obtener el
Fs 3D como promedio ponderado
considerando las áreas de las
diferentes secciones (Lambe
and Whitman, 1969;
Chowdhury 2010)

Generalmente $F_s 3D > F_s 2D$

$$F = \frac{F_1 A_1 + F_2 A_2 + F_3 A_3 + \dots}{A_1 + A_2 + A_3 + \dots}$$

Naturalmente hoy existen varios métodos completamente 3D



Tipos de superficies generables en una sección 2D:

- (1) **Circular** : definidas da círculo (arco de círculo: centro y rayo)
- (2) **espiral logarítmica**: eq. espiral logarítmica
- (3) **Genérica**: puntos (nodos) conectados con rectas (SSAP)
- (4) **Genéricas suavizadas**: superficie suavizada interpolante nodos (SSAP).

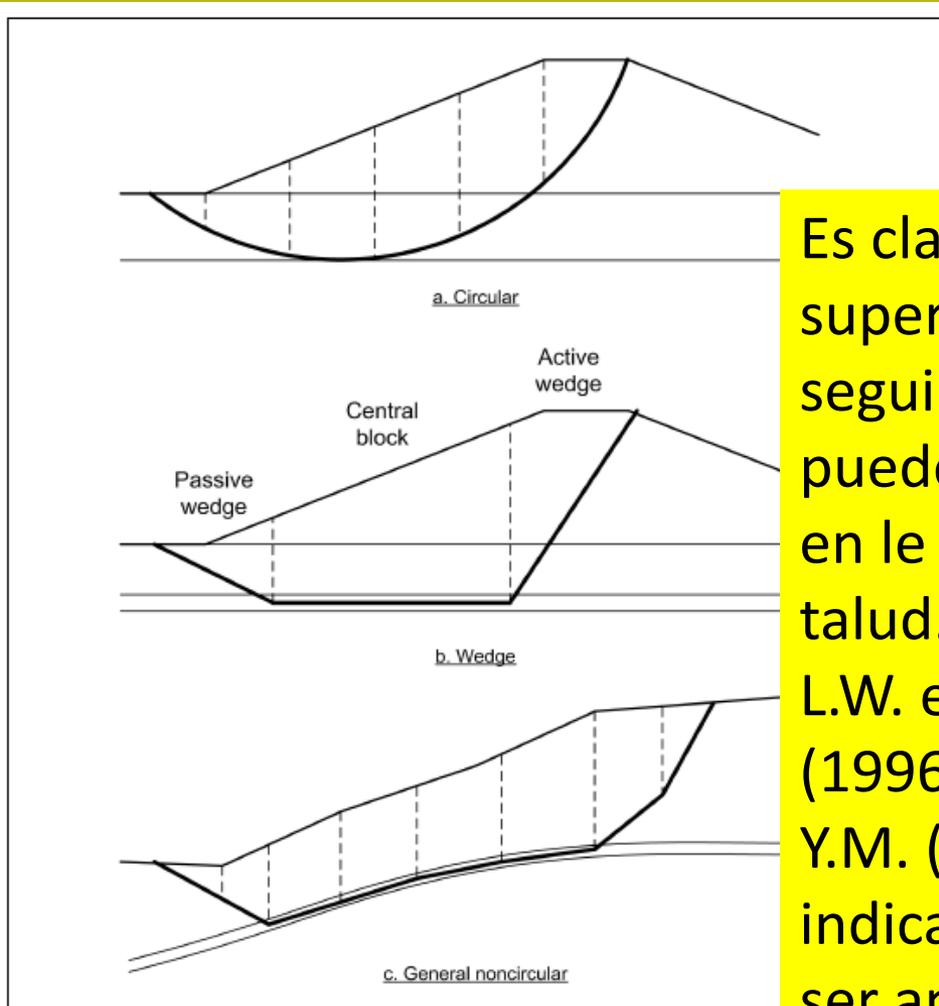
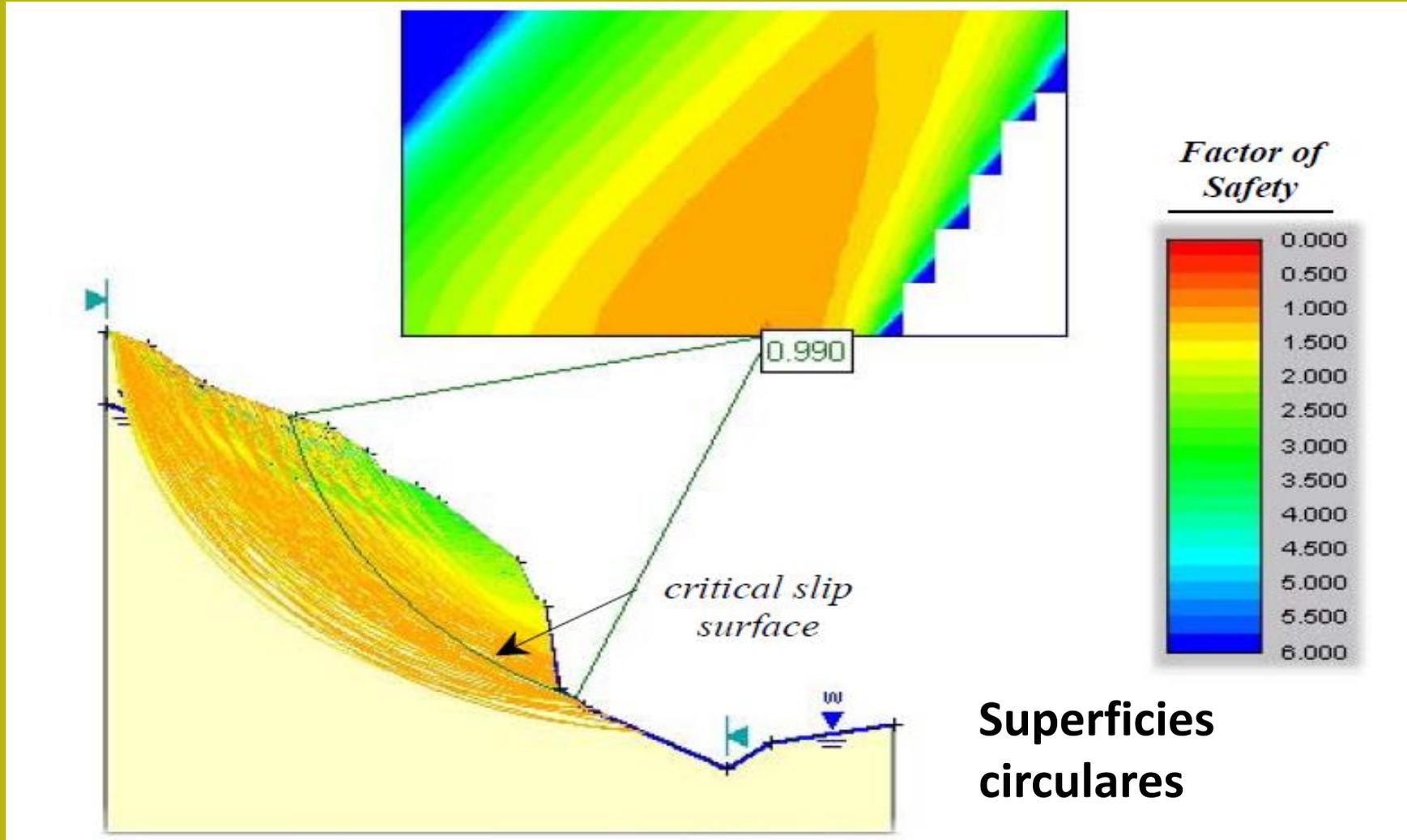
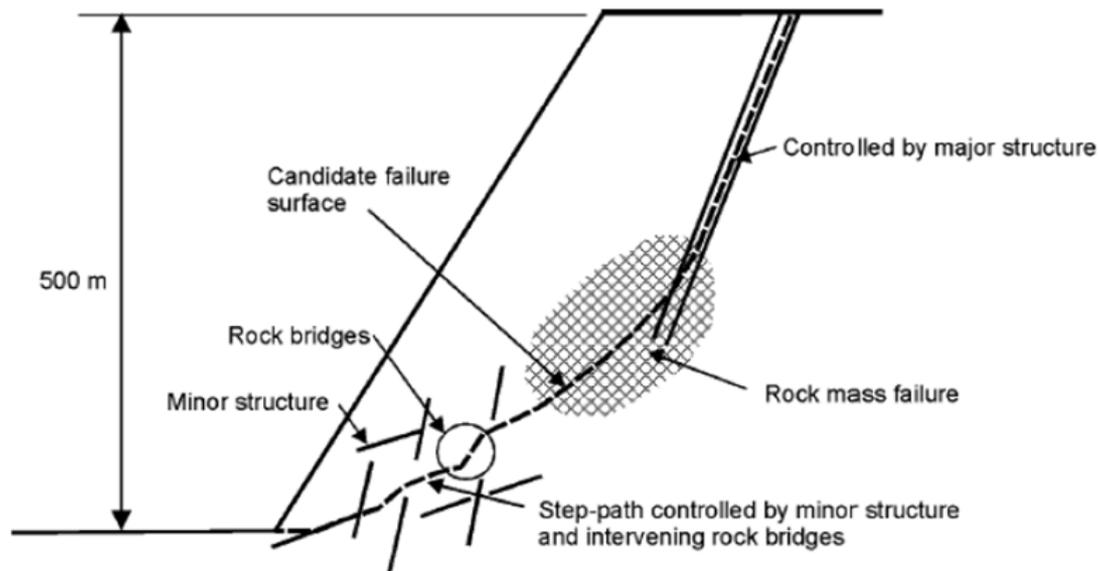
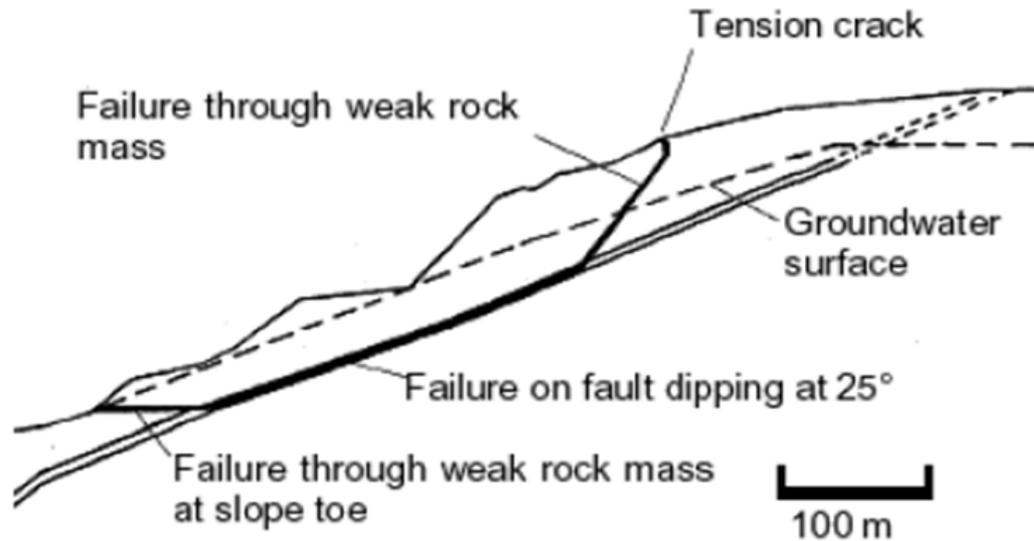


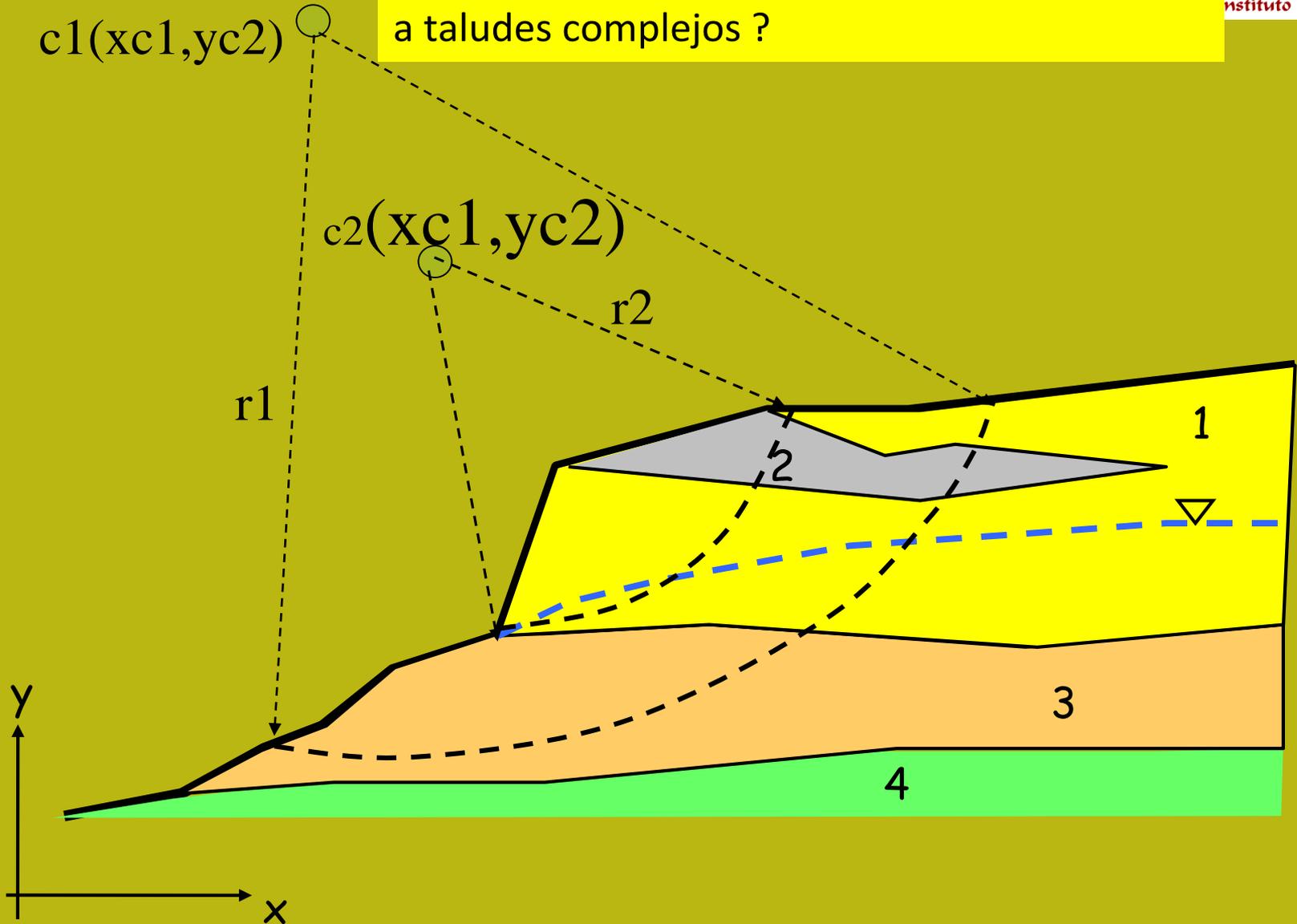
Figure C-3. Shapes for potential slip surfaces

Es claro que algunos tipo de superficies circulares no pueden seguir las discontinuidades que pueden haber una fuerte influencia en le grado de estabilidad del talud. Varios autores (ABRAMSON L.W. et al. (2002); DUNCAN J.M. (1996; SARMA S.K. (1979).; CHENG Y.M. (2003); JANBU N. (1973)) indican que el método LEM debe ser aplicado in manera diferente a pesar del grado de homogeneidad del talud y de posible discontinuidad estratigráficas y estructural.

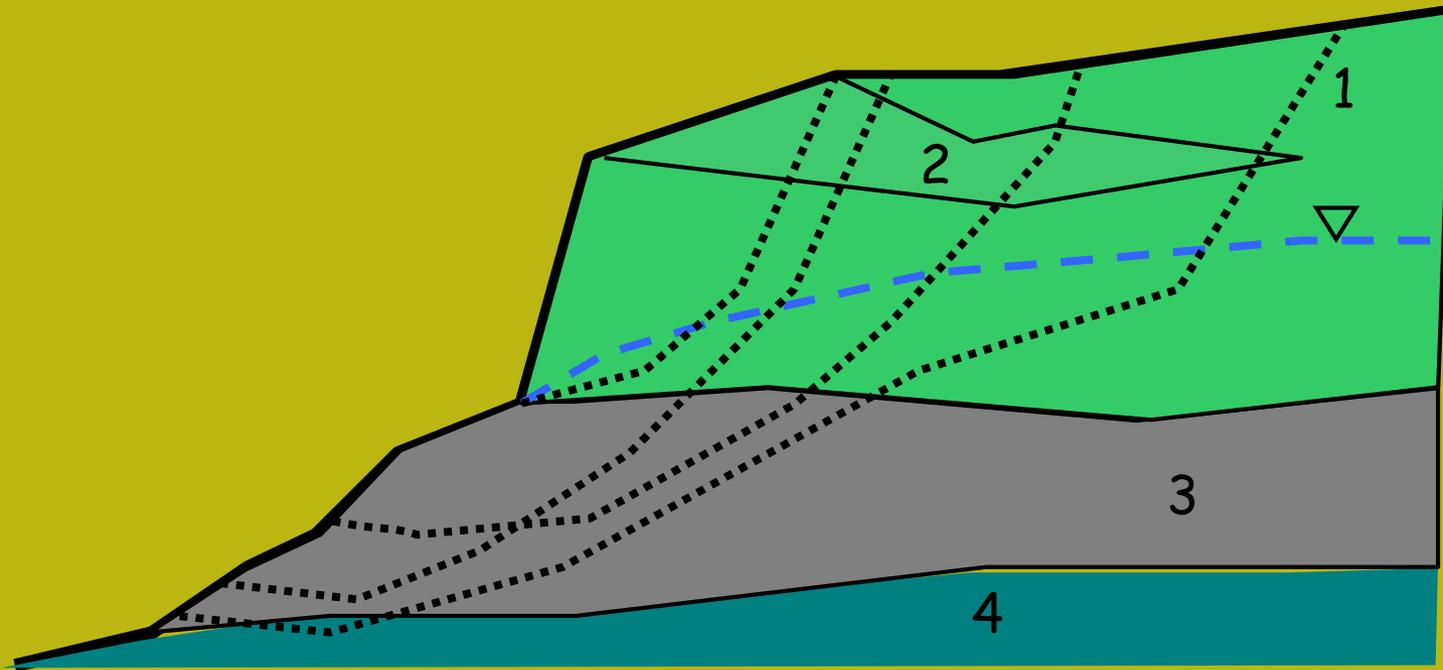




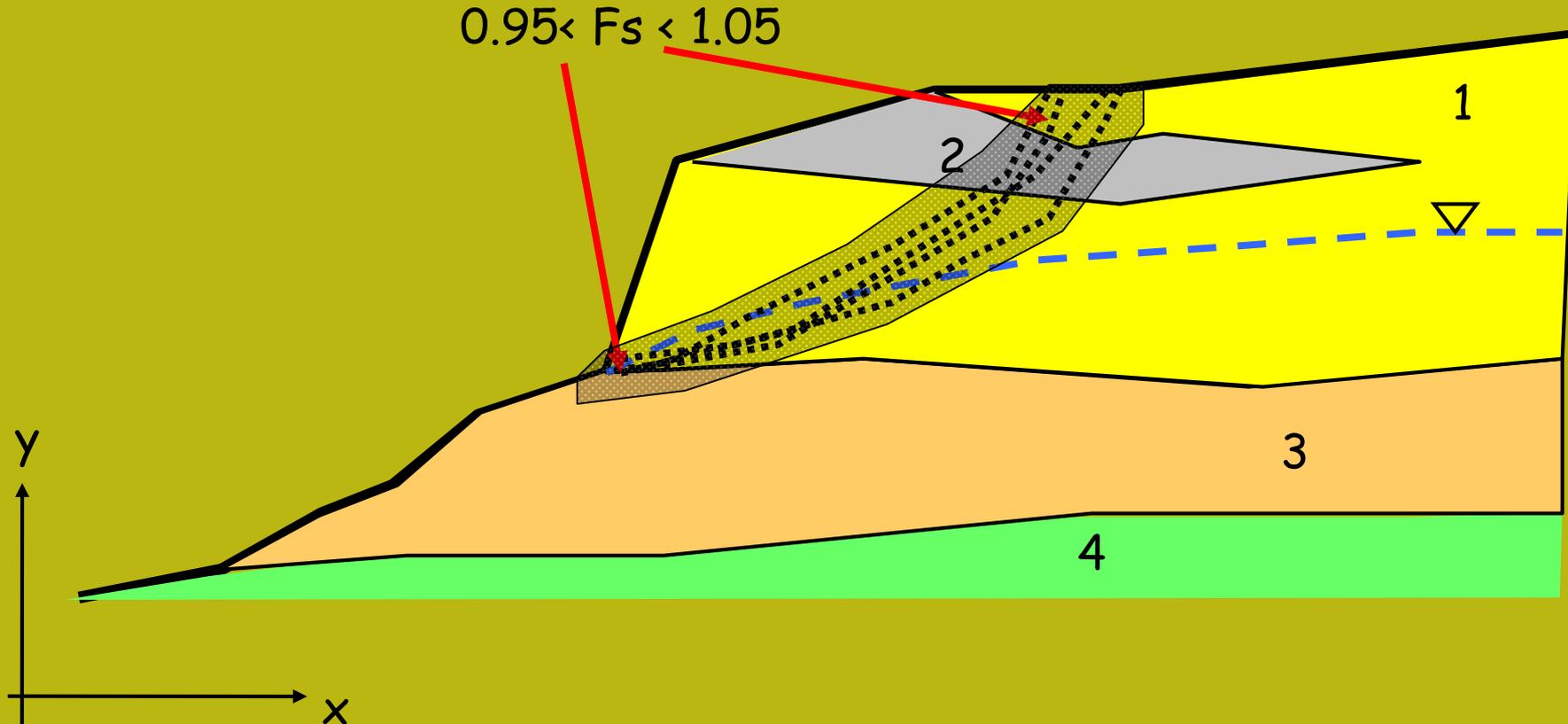
Pueden entonces
Sistemas simplificado como este ser aplicado
a taludes complejos ?



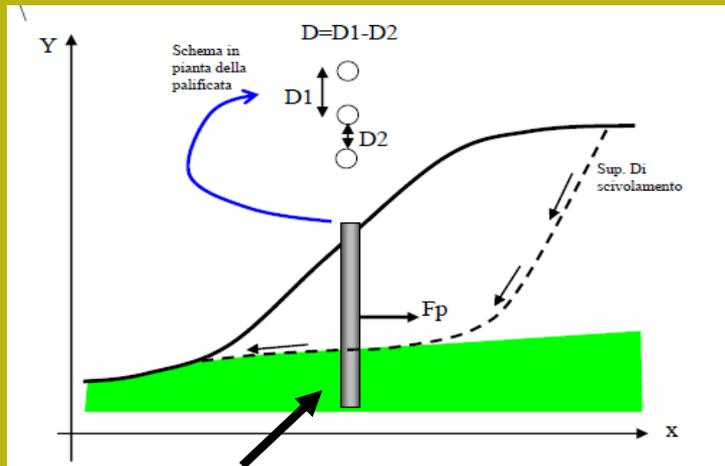
Una alternativa es la de generar superficies genéricas y mas complejas (suficientemente complejas) y en numero suficiente para explorar todas formas de deslizamiento posibles adentro el talud..



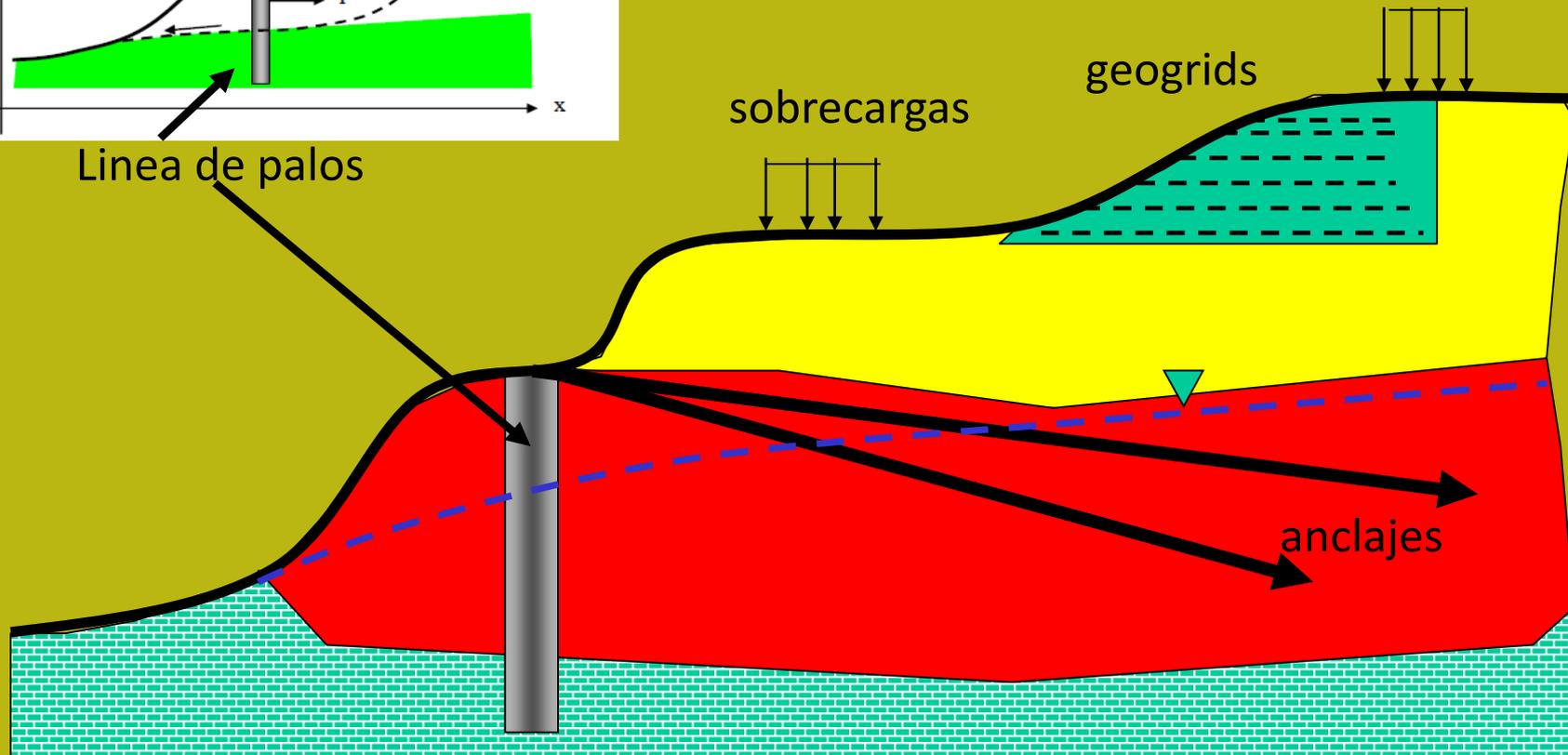
Y después la generación de una muestra significativa
de superficies visualizar
las con menor FS y identificar las áreas mas critica
adentro el talud



Complejidad generada da estructuras de contención



Linea de palos



Recursos y herramientas para modelado y manejo complejidad:

1. Levantamiento topográfico: secciones;
2. Levantamiento geológico – geo hidrológico, geotécnico, geofísico
3. Modelado geo-mecánico: parámetros, criterios de ruptura
4. Modelo de talud : incluye los puntos 1,2 3
5. Modelos de computo: técnicas de computo existentes (es. LEM; FEM)
6. Software (es. SSAP): una galaxia de software.. Escoger con mucho cuidado ...
7. y para terminar el recurso mas importante : **el conocimiento , la experiencia del geólogo y ingeniero, entonces el uso de nuestro cerebro!**

SSAP 2010 – 4.2.1 (2013) evaluación completa de la estabilidad de taludes naturales, o con obras de refuerzo, en suelos y macizos rocoso fracturados, por medio de motores de búsqueda estocástica de las superficie críticas y métodos de calculo rigurosos de el factor de seguridad, también en presencia de sismos. WWW.SSAP.EU

SSAP 2010 (versione 4.2.0 - 2012)

SLOPE STABILITY ANALYSIS PROGRAM
release 4.2.0 (c) (1991-2012)
Build No. 5845
by Dr. Geol. Lorenzo Borselli, Ph.D.
lorenzo.borselli@cnr.it
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AVVIO VERIFICA
VERIFICA GLOBALE
VERIFICA SINGOLA

RISULTATI
DIAGRAMMI FORZE
VEDI GRAFICI SUPERFICI
GENERA / VEDI MAPPA F_s LOCALE

MONITOR VERIFICA

MODELLO PENDIO
LEGGI MODELLO
VEDI MODELLO
HELP
ESCI dal PROGRAMMA

MODELLO PENDIO : **ES6.MOD**

MODELLO DI CALCOLO
MODELLO DI CALCOLO : **Morgestern e Price (1965)**
COEFFICIENTI SISMICI: ORIZZONTALE (K_h) : **0.0000**
VERTICALE (K_v) : **0.0000**

PARAMETRI ATTIVI PER GENERAZIONE SUPERFICI
MOTORE DI RICERCA SUPERFICI : **Convex Random Search (CRS)**
ZONA DI INIZIO - Progressive - (m) : **da 0.00 a 108.00**
ZONA DI TERMINAZIONE - Progressive - (m) : **da 12.00 a 117.60**
QUOTA LIMITE INTERIORE (m) : **0.00**
LUNGHEZZA MEDIA SEGMENTI - (m) : **4.80**
SMUSSA SUPERFICI: **Disattivato** EFFETTO TENSION CRACKS: **Attivato**
RICERCA CON ATTRATTORE DINAMICO: **Attivato** METODO (lambda=0.Fs0): **A**

RISULTATI IN TEMPO REALE
F_s ITERATIVO : **2.837**
RANGE F_s 10 SUPERFICI CON MINOR F_s : **1.440 - 1.521**
n. SUPERFICI GENERATE e VERIFICATE : **301 di 10000**
% EFFICIENZA GENERAZIONE SUPERFICI e % STABILITA' NUMERICA : **21.24 - 92.33**

PERCENTUALE SUPERFICI COMPLETATE: **3.01 %**

Premi ESC per Terminare - Premi INVIO/ENTER per stop temporaneo

SETUP VERIFICA
INFO
OPZIONI
PARAMETRI
GESTIONE ACQUIFERI
OPZIONI AGGIUNTIVE

STRUMENTI
GENERA REPORT VERIFICA
GENERA FILES DXF
ESPORTA SUPERFICI
CAMBIA PAR. GEOTECNICI
EDITA FILES
MAKEFILES 3.2
File SSAP2010.INI

MESSAGGI
SUGGERIMENTE: effettuata una verifica di stabilità è possibile generare un rapporto (file di testo) con tutti i risultati e anche una serie di file DXF con i grafici e esportare un file con le coordinate della superficie critica.

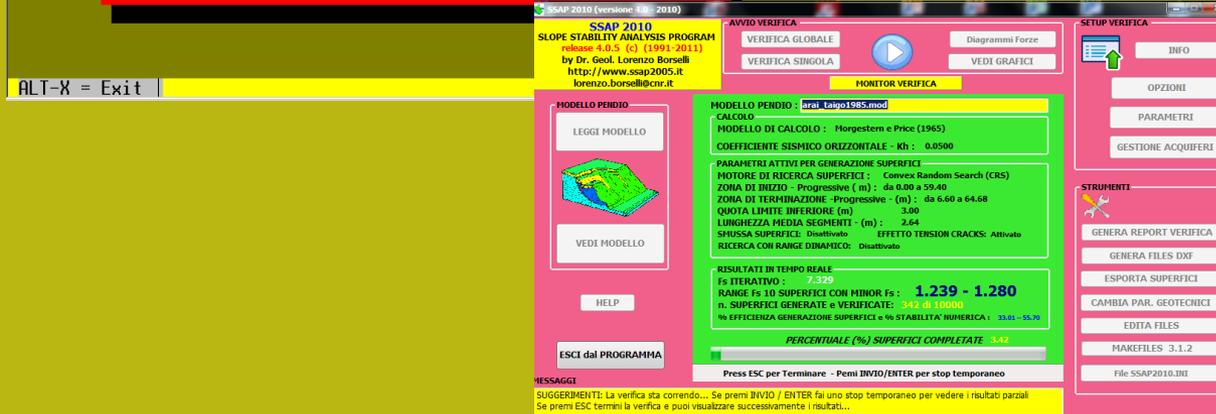
<http://WWW.SSAP.EU>

2003



2010

Da SSAP 2003
A SSAP 2010 4.1.3

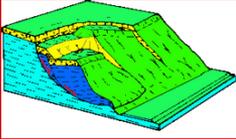


2012/2013



Este software se desarrollo en el curso de 21 años (1991-2012) Escribiendo da cero todas la rutinas de calculo y graficas..

Software interamente freeware (de uso libero , pero no open source)
 Por el momento es solo en Italiano.. Con un proyecto de traducción integral en español y ingles).



SSAP2010
(rel. 4.2.1)

versione PORTABLE
(installabile su chiavi USB e senza bisogno di configurazioni)

Caratteristiche generali

Manuale Tecnico (PDF)
(DISPONIBILE LA NUOVA VERSIONE AGGIORNATA, rel.4.2.1 ultima modifica : 8 marzo 2013)

AREA Download

Novità e Bug fixes
[note su update a versione 4.2.1 e ultimo aggiornamento del 08/03/2013]

Procedura installazione

Condizioni Licenza d'uso libero

Infos. Autore del software

The process of preparing programs for a digital computer is especially attractive, not only because it can be

SSAP2010

(SLOPE STABILITY ANALYSIS PROGRAM)

Versione 4.2.1 (2012)
(8 marzo 2013)

Software Interamente Freeware

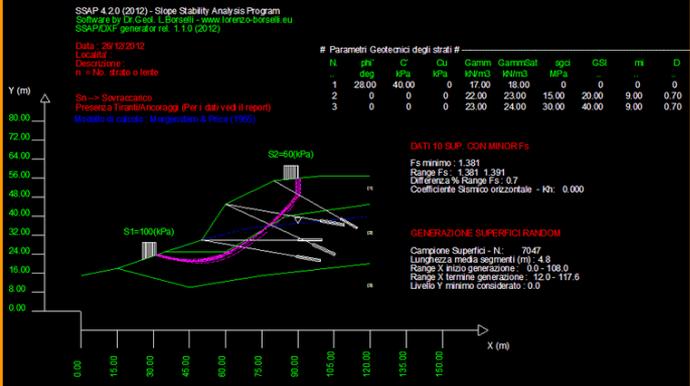
Completamente Gratuito e di utilizzo libero per Privati, Ingegneri, Geologi, Studenti e Pubbliche Amministrazioni (vedasi licenza d'uso)

NOVITA'

CORSI SSAP (2013)

CORSO BASE (Firenze, 21-22 gennaio 2013) - programma corso
CORSO AVANZATO (Firenze, 24-25 Gennaio 2013) - programma corso

Informazioni e iscrizione:
FONDAZIONE DEI GEOLOGI DELLA TOSCANA (ente no profit)



# Parametri Geotecnici degli strati #										
N	gr	C	Cu	Gamm	GammSat	sgd	GSI	m	D	
	deg	kPa	kPa	kN/m3	kN/m3		MPa			
1	28.00	40.00	0	17.00	18.00	0	0	0	0	0
2	0	0	0	22.00	23.00	15.00	20.00	9.00	0.70	
3	0	0	0	23.00	24.00	30.00	40.00	9.00	0.70	

Ejemplo de interfaz usuario en Windows 7: La versión SSAP 4.2.1 – portable (puede operar también en Linux Con emulador WINE 1.2 y en Mac-OS en Wmware virtual machine)

SSAP 2010 (versione 4.1.3 - 2012)

SLOPE STABILITY ANALYSIS PROGRAM
release 4.1.3 (c) (1991-2012)
Build No. 5770
by Dr. Geol. Lorenzo Borselli, Ph.D.
lorenzo.borselli@cnr.it
<http://www.lorenzo-borselli.eu>

AVVIO VERIFICA
VERIFICA GLOBALE
VERIFICA SINGOLA

RISULTATI
DIAGRAMMI FORZE

SETUP VERIFICA
INFO

OPZIONI GENERALI per Verifiche di Stabilità SSAP 4.1.3

Coefficiente sismico orizzontale - Kh: 0.000

Fs di Progetto richiesto (analisi deficit): 1.100

METODO DI CALCOLO
 JANBU RIGOROSO - (1973)
 SPENCER - (1973)
 SARMA I - (1973)
 MORGESTERN PRICE - (1965)
 CORREIA - (1988)
 SARMA II - (1979)

Esplora spazio (lambda0,fs0) Metodo
 A (rapido e accurato)
 B (più accurato)
 C (molto più accurato)

CONTROLLO STABILITÀ NUMERICA
 % Tolleranza stress normali negativi: 0%
 % Tolleranza $RHO = |Fs/Fv| > 1.0$: 100%
 LIMITATO
 Non LIMITATO

MOTORE GENERAZIONE E RICERCA SUPERFICI
 RANDOM SEARCH (RS)
 CONVEX RANDOM SEARCH (CRS)
 SNIFF RANDOM SEARCH (SRS) 2.0

SOLO PER MOTORE SNIFF RANDOM SEARCH
 Steps di scansione: 60
 Frequenza di attivazione: 0.75

FILTRAGGIO SUPERFICI
 FILTRARE
 NON FILTRARE

PRESENZA DI OSTACOLO
 CON OSTACOLO INTERNO
 SENZA OSTACOLO INTERNO

TIRANTI - ANCORAGGI
 PASSIVI
 ATTIVI

PALIFICATE - Metodo calcolo
 ITO-MATSUI (1975) - HASSIOTIS (1997)
 KUMAR-HALL (2006) (+ conservativo)

PALIFICATE fattore riduttivo NTC2008
 Fattore di riduzione (Variare da 1 a 10): 1.00

SMUSSA SUPERFICI DI SCIVOLAMENTO
 EFFETTO ATTIVATO
 EFFETTO DISATTIVATO

TENSION CRACKS TESTA PENDIO
 EFFETTO DISATTIVATO
 EFFETTO ATTIVATO

FORZE AGGIUNTIVE PER SUPERFICIE SINGOLA
 Forza Ea (alla Base) - kN/m: 0.00
 Forza Eb (in Testa) - kN/m: 0.00

ATTRATTORE DINAMICO RICERCA SUPERFICI
 DISATTIVATO
 ATTIVATO

MODELLO PENDIO
 LEGGI MODELLO
 VEDI MODELLO
 HELP

MODELLO PENDIO: ES6.MOD
 MODELLO DI CALCOLO: Morgestern e Price (1965)
 COEFFICIENTI SISMICI: ORIZZONTALE (Kh): 0.0000
 VERTICALE (Kv): 0.0000

PARAMETRI ATTIVI PER GENERAZIONE SUPERFICI
 MOTORE DI RICERCA SUPERFICI: Convex Random
 ZONA DI INIZIO - Progressive - (m): da 0.00
 ZONA DI TERMINAZIONE - Progressive - (m): da 12.00
 LUNGHEZZA MEDIA SEGMENTI - (m): 3.00
 SMUSSA SUPERFICI: Disattivato EFFETTO TENSION: Attivato
 RICERCA CON ATTRATTORE DINAMICO: Attivato METODO: Random

RISULTATI IN TEMPO REALE
 Fs ITERATIVO: 1.597
 RANGE Fs 10 SUPERFICI CON MINOR Fs: 1.367 -
 n. SUPERFICI GENERATE e VERIFICATE: 10000 di 10000
 % EFFICIENZA GENERAZIONE SUPERFICI e % STABILITÀ NUMERICA: 100% di 100%

PERCENTUALE SUPERFICI COMPLETATE

Premi ESC per Terminare - Premi INVIO/ENTER per step successivo

MESSAGGI
 SUGGERIMENTI: effettuata una verifica di stabilità è possibile generare un rapporto (file di testo) con tutti i risultati e anche una serie di file DXF con i grafici e esportare un file con le coordinate della superficie critica.

OK Cancel

SSAP 4.1.3 -Ventana principal y ventana de opciones

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AVVIO VERIFICA
 VERIFICA GLOBALE
 VERIFICA SINGOLA

RISULTATI
 DIAGRAMMI FORZE
 VEDI GRAFICI

SETUP VERIFICA
 INFO

STABILITY OF ROCK S...

MODELLO PENDIO
 LEGGI MODELLO
 VEDI MODELLO
 HELP

SSAP2010 rel. 4.1.3

MESSAGGI
 SUGGERIMENTI: effettuata una verifica e anche una serie di file DXF con i graf

DjView GridConvert LandSerf 2.3

gnuplot graph

Options

1 2 3 4 5 6 7 8 9 10

Pressioni neutre e coeff. ru

U(x) (kPa) ru (-)

X (m)

10/11/12 19:23

Forze interconco

E(x)(kN/m) T(x)(kN/m)

X (m)

10/11/12 19:23

Sup. Minimo Fs, Thrust line, local FS

Y (m) local FS

X (m)

10/11/12 19:23

Fattore Rho e pressione normale N' su sup. min. FS

rho(x) N'(kPa)

X (m)

10/11/12 19:23

SSAP2010 (versione 4.1.3 2012) - DISTRIBUZIONE FORZE e PRESSIONI

x=-73.8075 y= 0.355685 y2= 412.245

Ejemplo de interfaz usuario

SSAP 4.1.3 - ventana gráficos múltiples de distribución de fuerzas internas y presiones

GESTIONE ACQUIFERI

ACQUIFERI DISATTIVABILI

Acquifero Strato 1

Acquifero Strato 2

Acquifero Strato 3

CARATTERISTICHE FLUIDO

Gamma fluido (kN/m³)

Coefficiente A

Coefficiente K

Uo minima (kPa)

GESTIONE PIEZOMETRICHE

Esclusione sovraccarichi pendii sommersi

Esclusione sovraccarico fino alla Progressiva (m)

Prima di modificare i valori pre-impostati dal programma ricordarsi che è necessario leggere il manuale tecnico del programma di queste procedure può portare ad effetti sui risultati delle verifiche.

HELP

Ejemplo de interfaz usuario :

Gestione acuíferos y parámetros de generaciones superficies random

PARAMETRI GEOMETRICI VERIFICHE DI STABILITA'

LUNGHEZZA MEDIA (m) SEGMENTI DELLE SUPERFICI DI SCIVOLAMENTO

DEFINIZIONE DELLA ZONA DI INIZIO

ASCISSA LIMITE SINISTRO (X1) ZONA DI INIZIO (m)

ASCISSA LIMITE DESTRO (X2) ZONA DI INIZIO (m)

QUOTA (Yo) ZONA PROIBITA INFERIORE (m)

DEFINIZIONE DELLA ZONA DI TERMINAZIONE

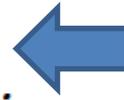
ASCISSA LIMITE SINISTRO (X1) DI TERMINAZIONE (m)

ASCISSA LIMITE DESTRO (X2) DI TERMINAZIONE (m)

NUMERO MASSIMO SUPERFICI DA GENERARE

NOTA BENE: Tutte le coordinate sono espresse in metri (vedasi manuale per descrizione PARAMETRI)..

- *Janbu rigoroso*(1973);
- *Spencer* (1973)
- *Sarma I* (1973);
- *Morgenstern & Price* (1965);
- *Correia* (1988)
- *Sarma II* (1979)

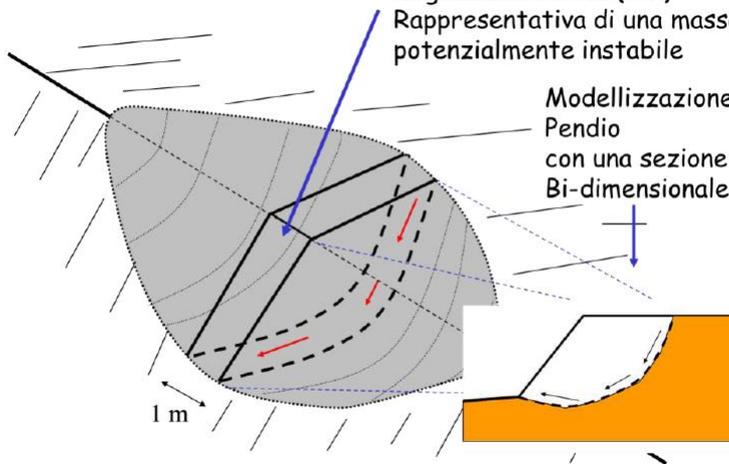


Verifica de estabilidad con
método de equilibrio limite (LEM)
Exclusivamente métodos de cálculo
Rigurosos:

Verifica di stabilità 3D→2D

Verifica su striscia di
larghezza unitaria (1 m)
Rappresentativa di una massa
potenzialmente instabile

Modellizzazione
Pendio
con una sezione
Bi-dimensionale

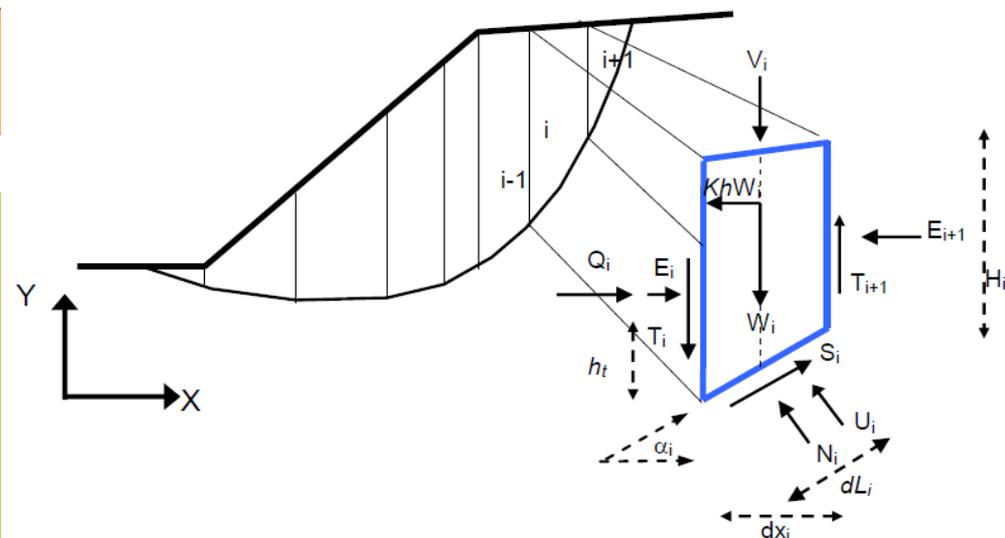


$$\left\{ \begin{aligned} F_s &= \frac{f(N_{(x)}, U_{(x)}, \alpha_{(x)}, T_{(x)}, V_{(x)}, dx_{(x)}, Q_{(x)}, Fs)}{f(\alpha_{(x)}, W_{(x)}, V_{(x)}, dx_{(x)}, T_{(x)}, \lambda)} \\ \lambda &= \frac{f(dx_{(x)}, E_{(x)}, \alpha_{(x)}, W_{(x)}, V_{(x)}, Q_{(x)})}{f(dx_{(x)}, T_{(x)}, \lambda)} \end{aligned} \right.$$

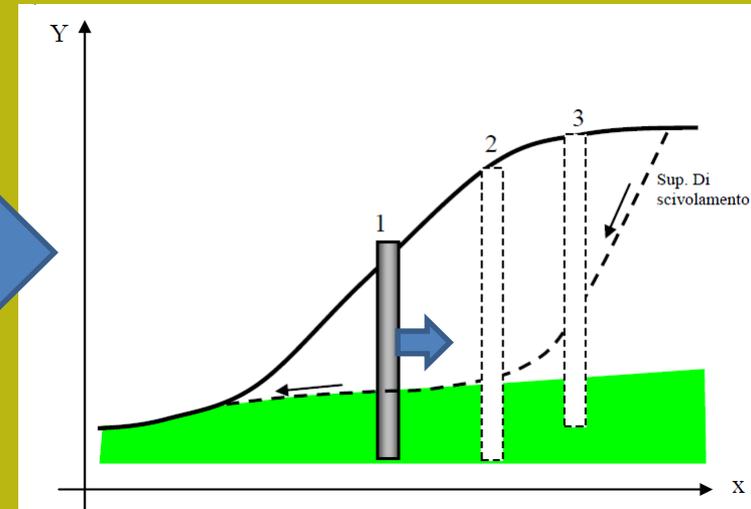
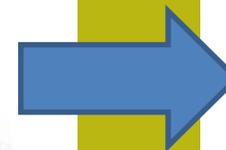
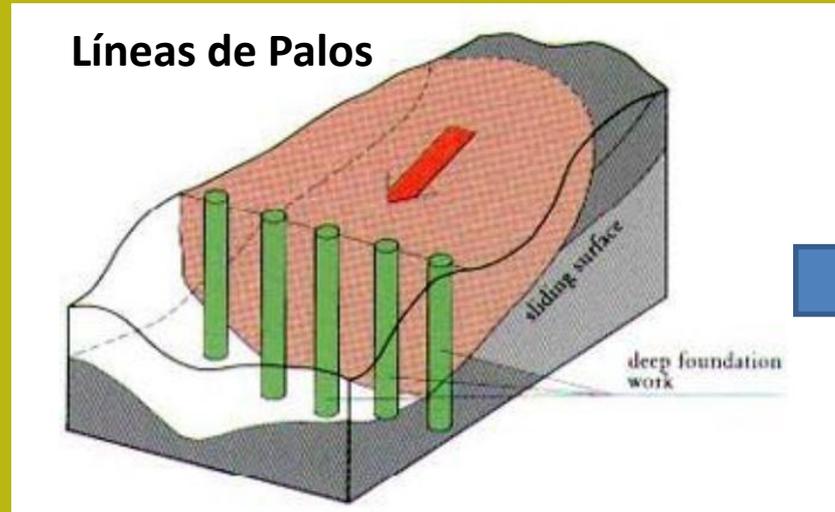
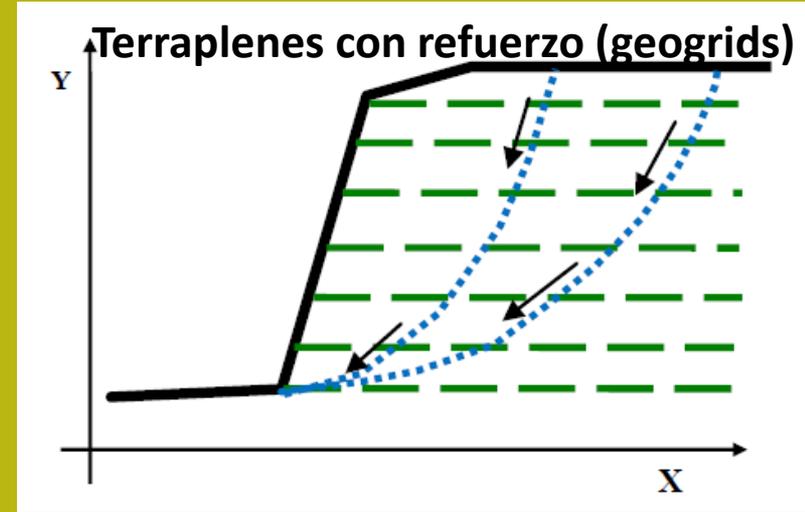
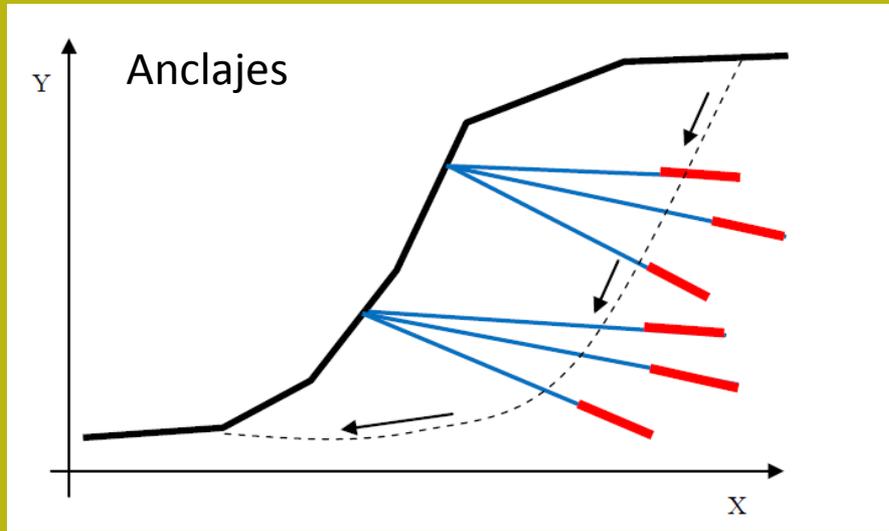
Da Borselli(2013).

Manual SSAP2010 rel. 4.2.1

www.ssap.eu/manuale_ssap2010.pdf



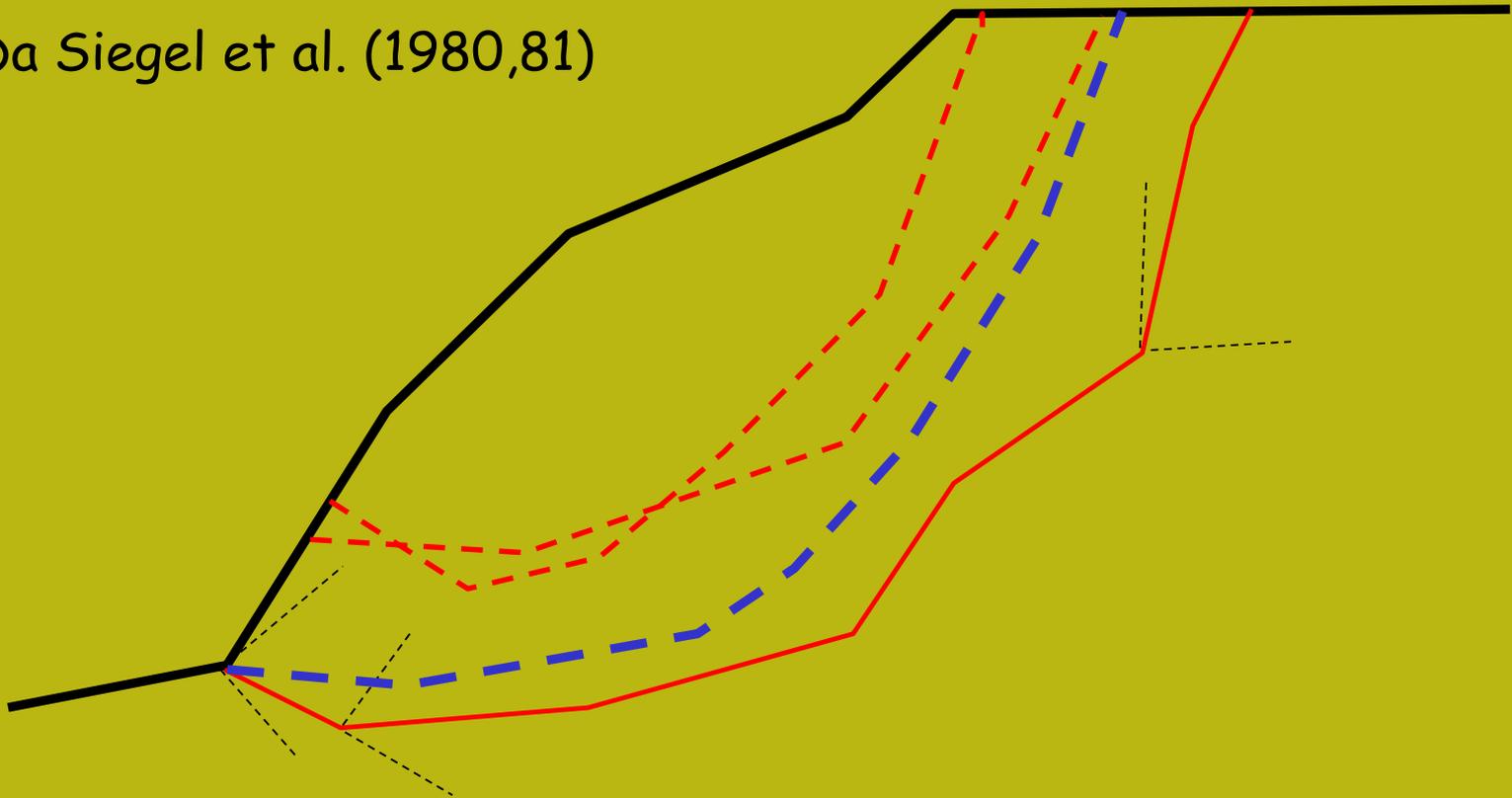
Elementos y de refuerzo Y obras que es posible incluir en SSAP

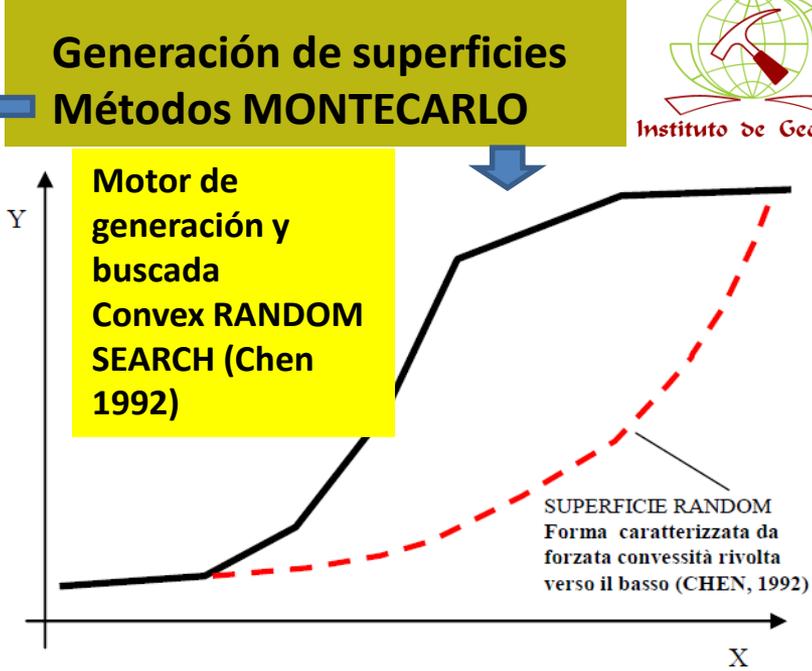
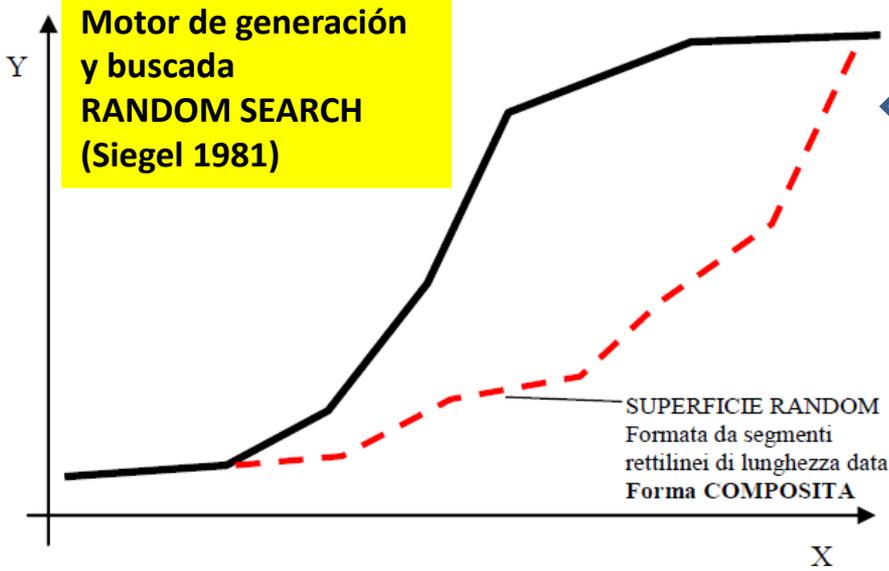


Superficies genéricas - Generación random montecarlo

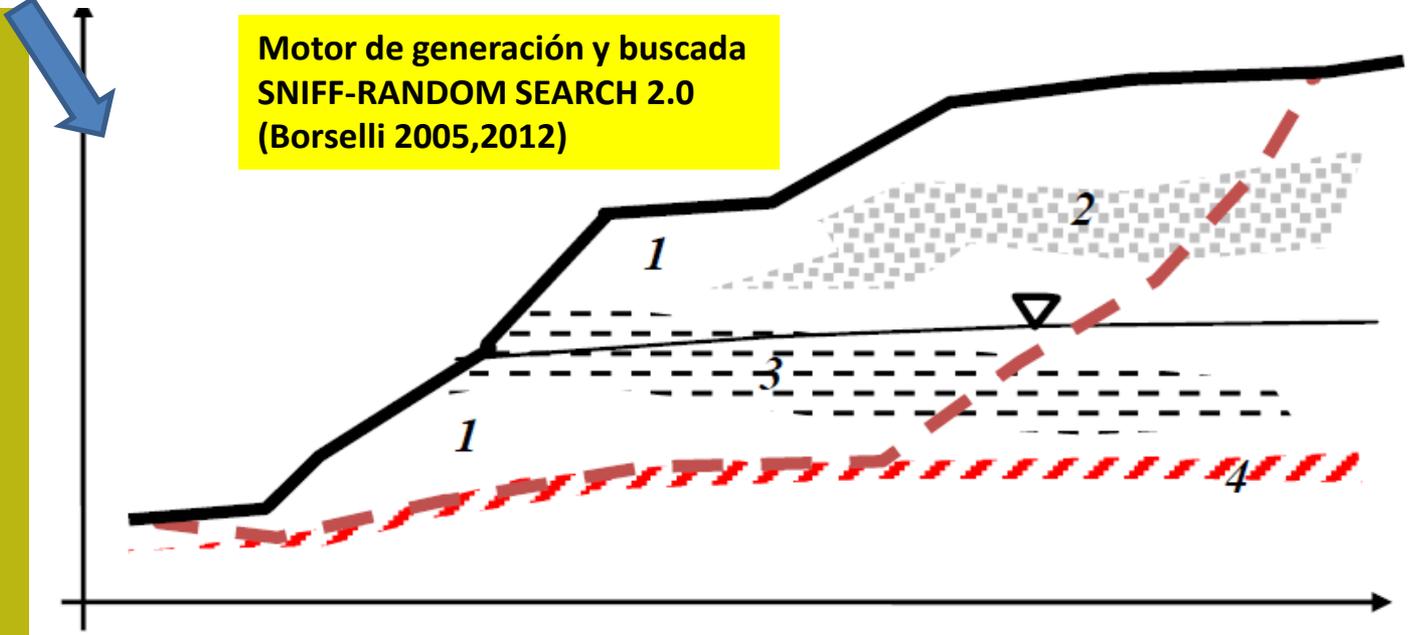
Disfruta la posibilidad de la computadora de generar secuencias infinitas de números aleatorios (random)

Da Siegel et al. (1980,81)





**Generación de superficies. Metodo Hibrido
(Sistema experto + Montecarlo)**



Los diferentes motores de generación y búsqueda de SSAP (con su 9 variantes) pueden tratar caso complejos como este..

SSAP 4.2.0 (2012) - Slope Stability Analysis Program
Software by Dr. Geol. L.Borselli - www.lorenzo-borselli.eu
SSAP/DXF generator rel. 1.1.0 (2012)

Parametri Geotecnici degli strati

N.	phi` deg	C` kPa	Cu kPa	Gamm kN/m3	GammSat kN/m3	sgci MPa	GSI	mi	D
1	27.45	2.00	0	19.10	19.10	0	0	0	0
2	21.32	28.00	0	19.75	19.75	0	0	0	0
3	29.26	0	0	19.10	19.10	0	0	0	0
4	21.32	0	0	19.50	19.50	0	0	0	0
5	27.45	2.00	0	19.10	19.10	0	0	0	0
6	29.26	0	0	19.10	19.10	0 </tr			

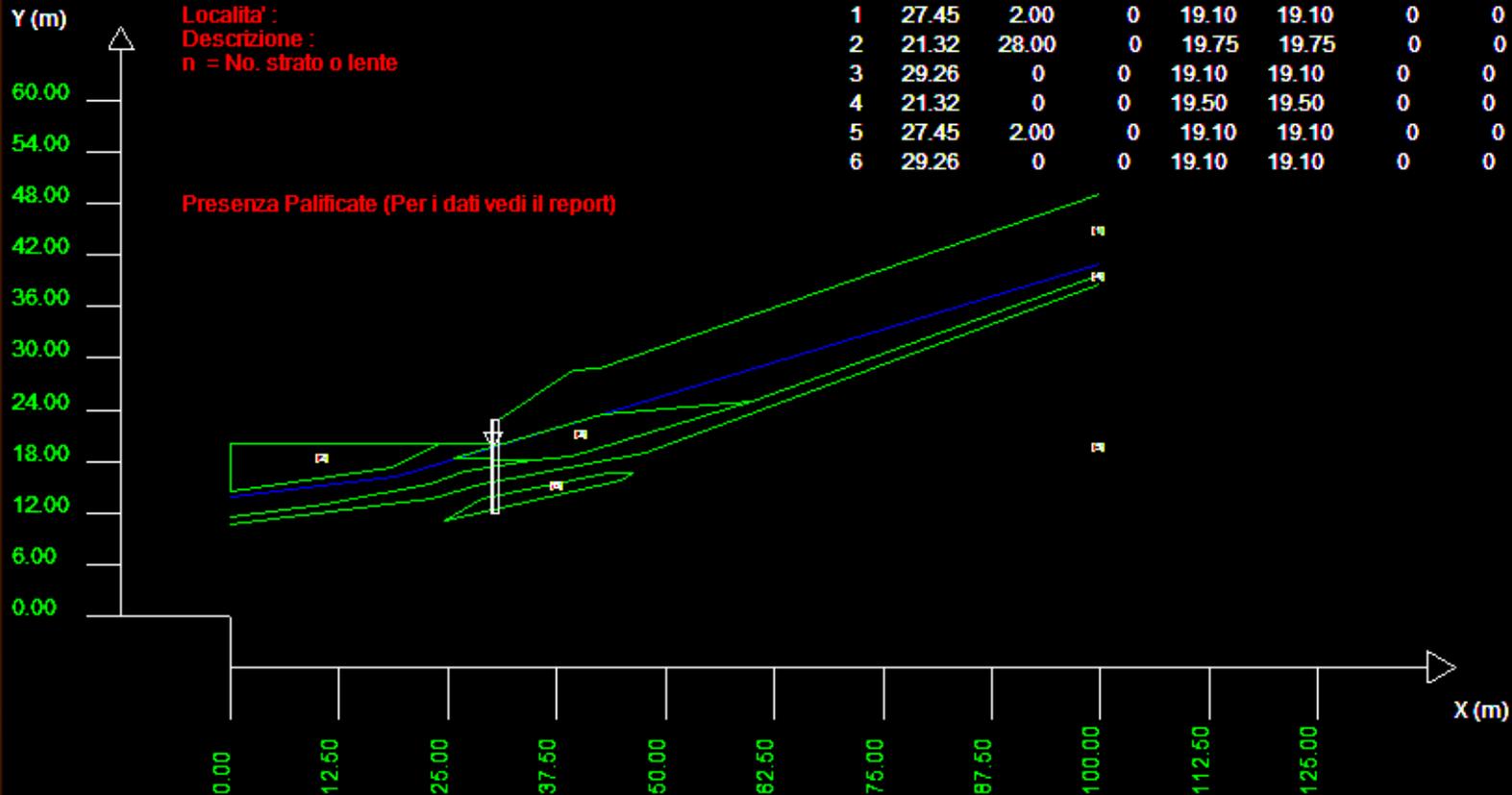
Data : 14/1/2013

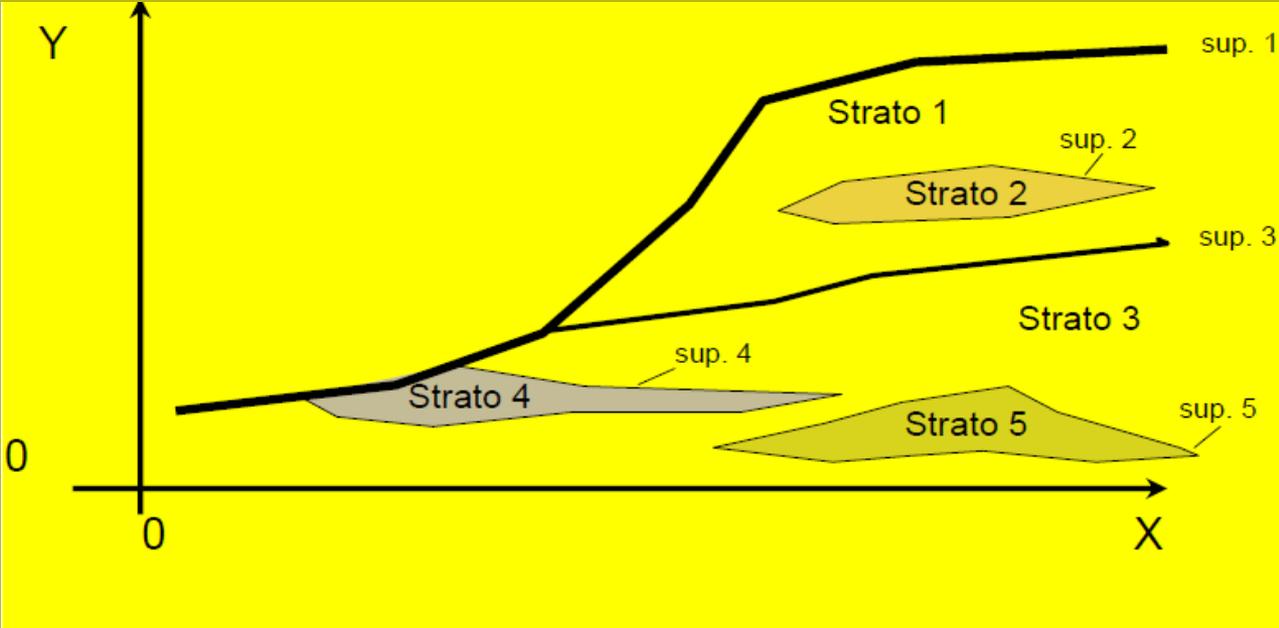
Localita' :

Descrizione :

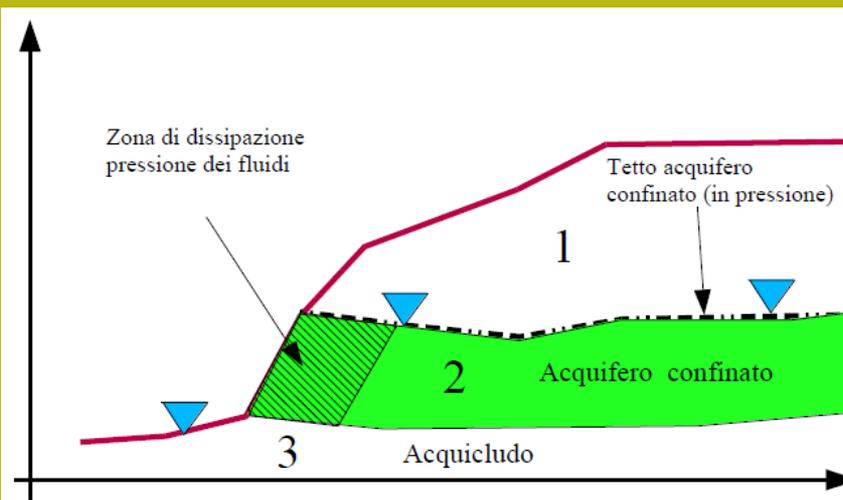
n = No. strato o lente

Presenza Palificate (Per i dati vedi il report)





**Complejidad
estratigráfica
Max(20 estratos)**



**Módulo Gestión acuíferos hasta in presión,
superficiales y temporáneos colgados**

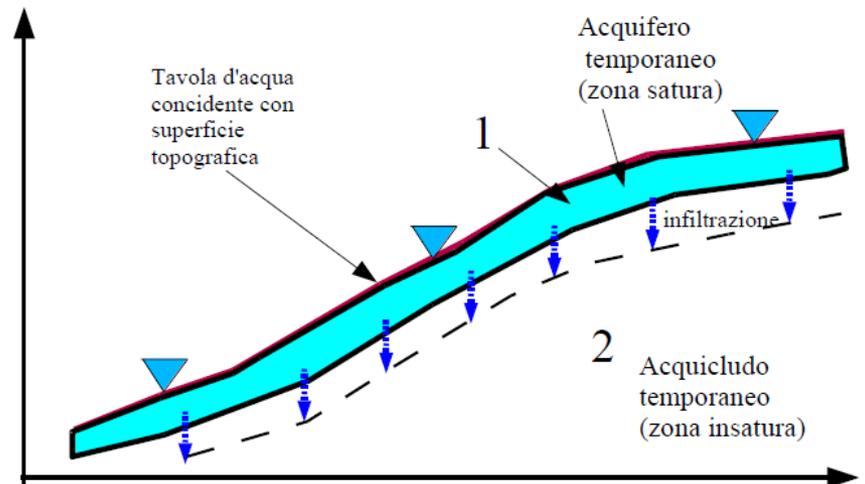
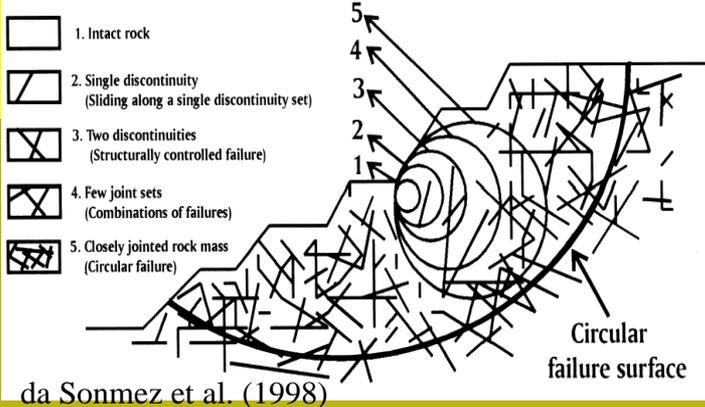
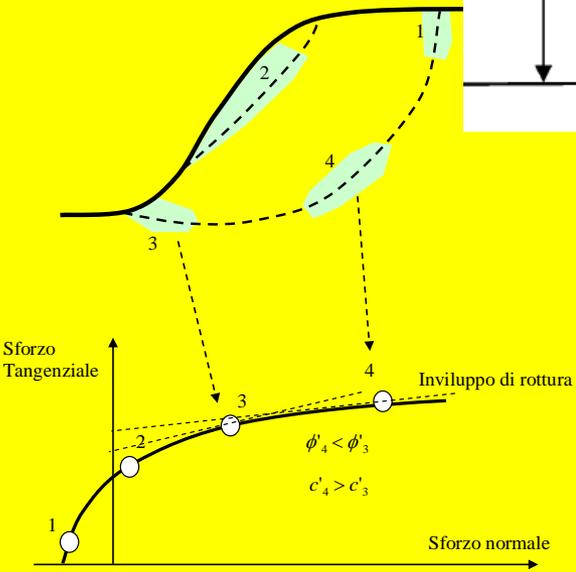
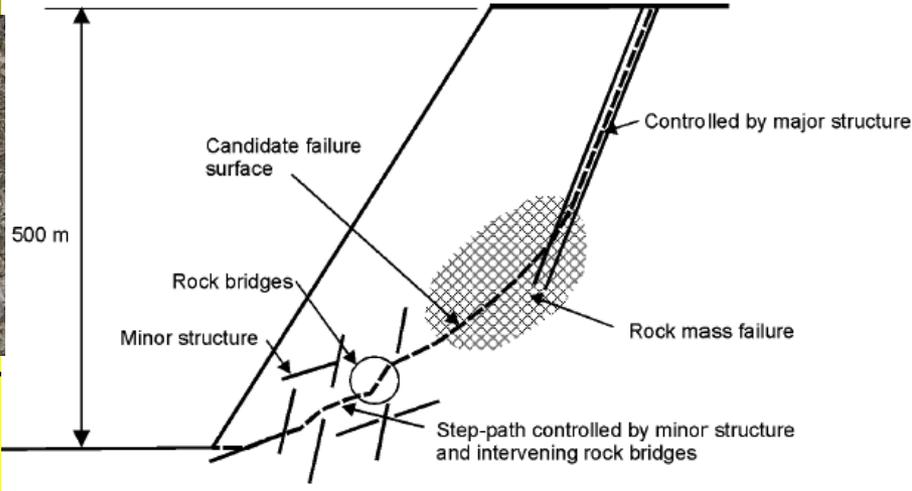


Figura E.2

Aplicación en macizo rocosos por medio de criterio de ruptura de Hoek et al 2002-2007 y clasificación GSI del macizo rocoso fracturado



da Sonmez et al. (1998)

STRUCTURE	TYPICAL PROBLEMS
Landslides.	Complex failure along a circular or near circular failure surface involving sliding on faults and other structural features as well as failure of intact materials.
Soil or heavily jointed rock slopes.	Circular failure along a spoon-shaped surface through soil or heavily jointed rock masses.
 Jointed rock slopes.	Planar or wedge sliding on one structural feature or along the line of intersection of two structural features.
 Vertically jointed rock slopes.	Toppling of columns separated from the rock mass by steeply dipping structural features which are parallel or nearly parallel to the slope face.
 Loose boulders on rock slopes.	Sliding, rolling, falling and bouncing of loose rocks and boulders on the slope.

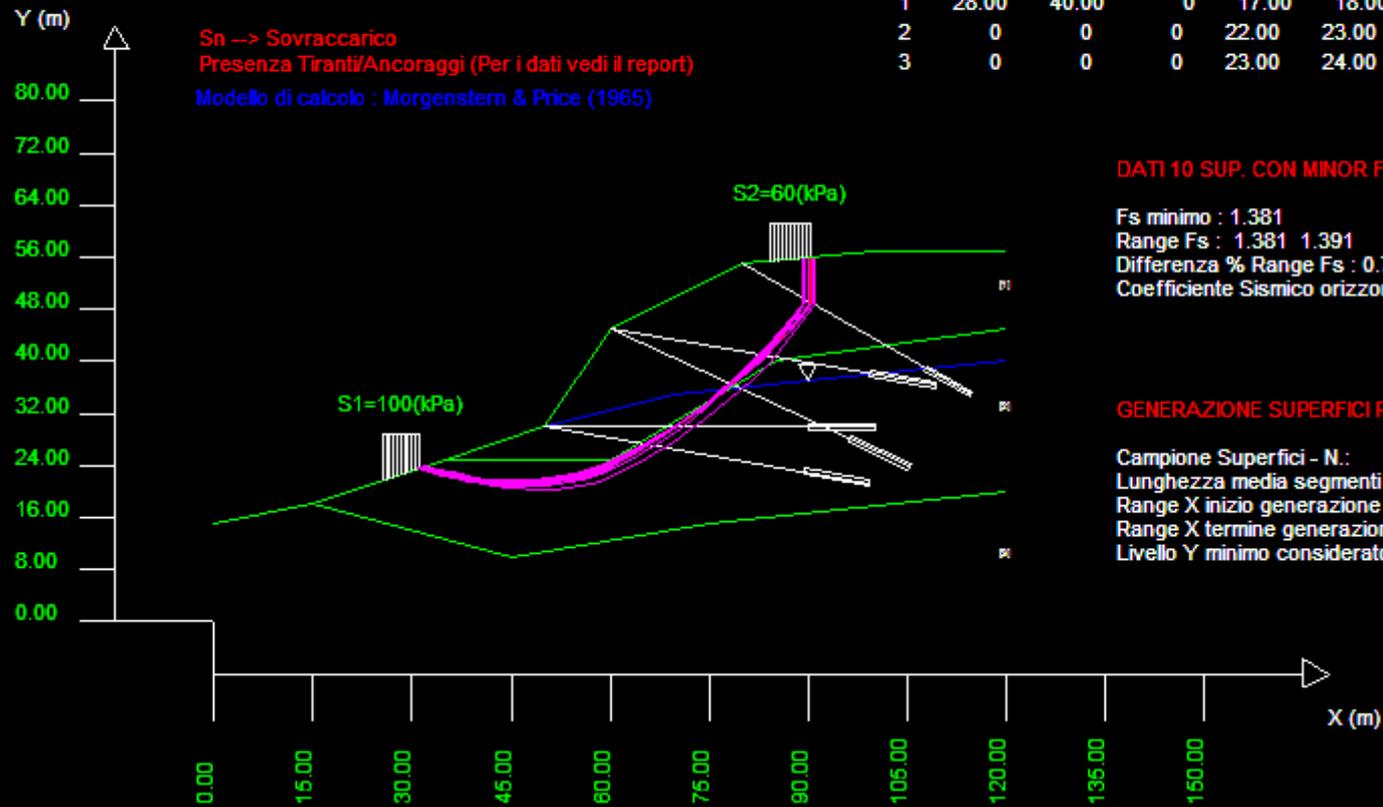
SSAP 4.2.0 (2012) - Slope Stability Analysis Program
Software by Dr. Geol. L. Borselli - www.lorenzo-borselli.eu
SSAP/DXF generator rel. 1.1.0 (2012)

Data : 26/12/2012
Localita' :
Descrizione :
n = No. strato o lente

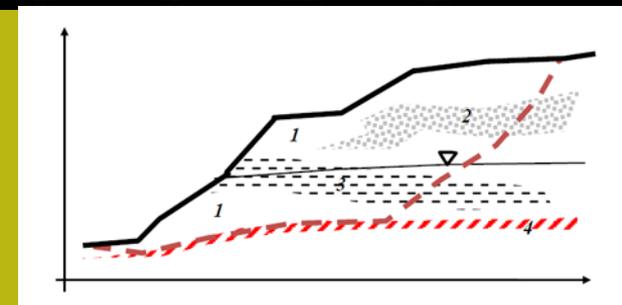
Parametri Geotecnici degli strati

N.	phi ⁱ deg	C ⁱ kPa	Cu kPa	Gamm kN/m3	GammSat kN/m3	sgci MPa	GSI	mi	D
1	28.00	40.00	0	17.00	18.00	0	0	0	0
2	0	0	0	22.00	23.00	15.00	20.00	9.00	0.70
3	0	0	0	23.00	24.00	30.00	40.00	9.00	0.70

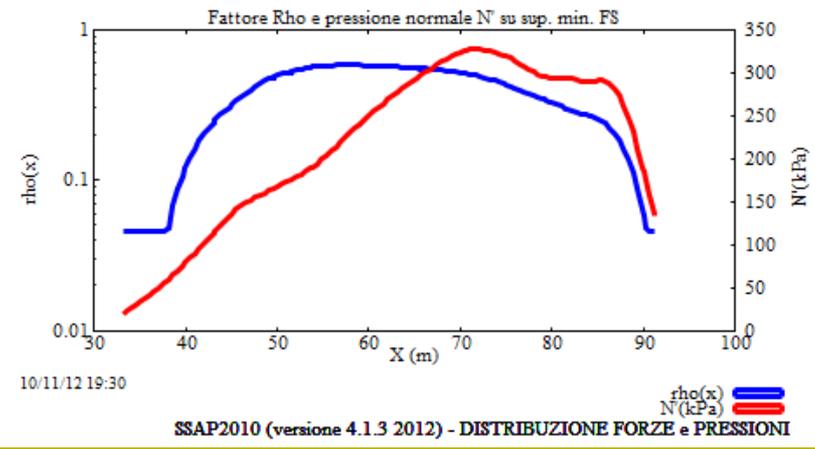
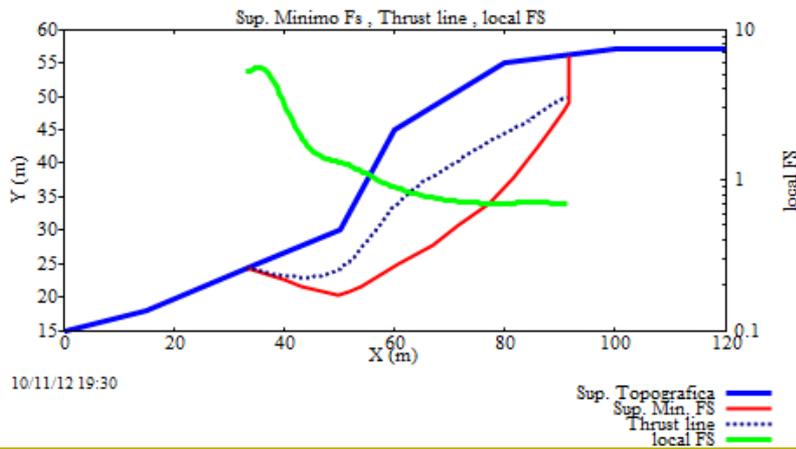
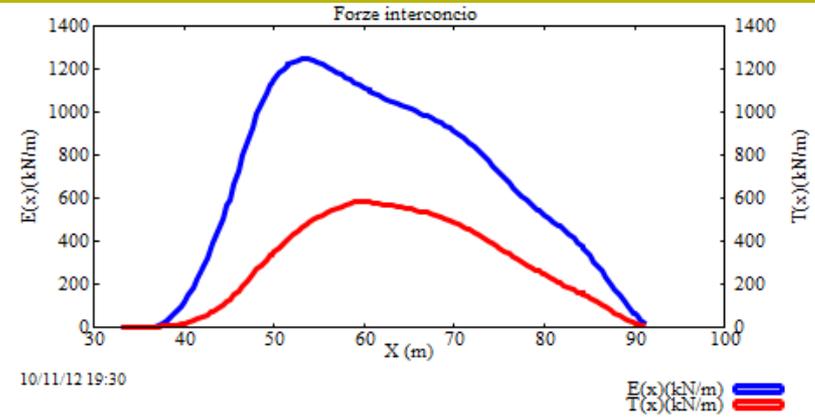
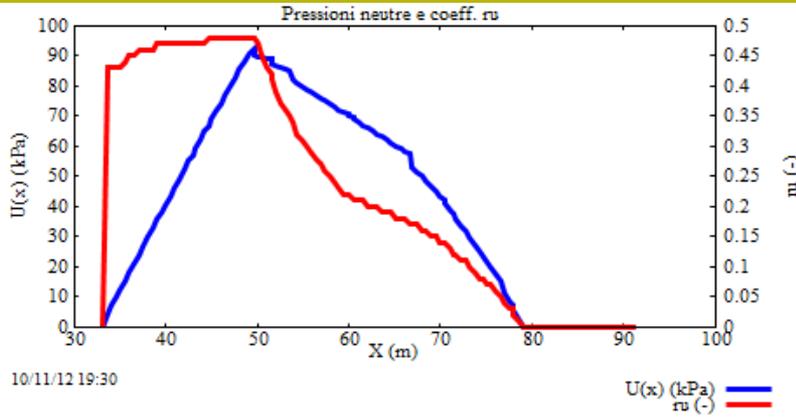
Sn -> Sovraccarico
Presenza Tiranti/Ancoraggi (Per i dati vedi il report)
Modello di calcolo : Morgenstern & Price (1965)



Aplicación de SNIFF RANDOM SEARCH 2.0 A terrapleno con base no firme (ejemplo da Fredlund 1977)

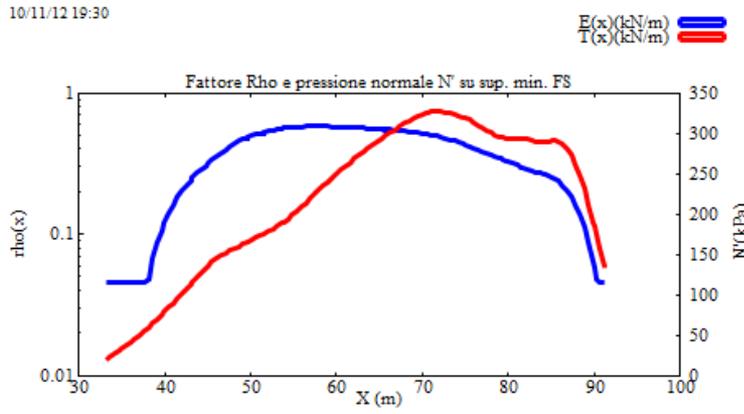
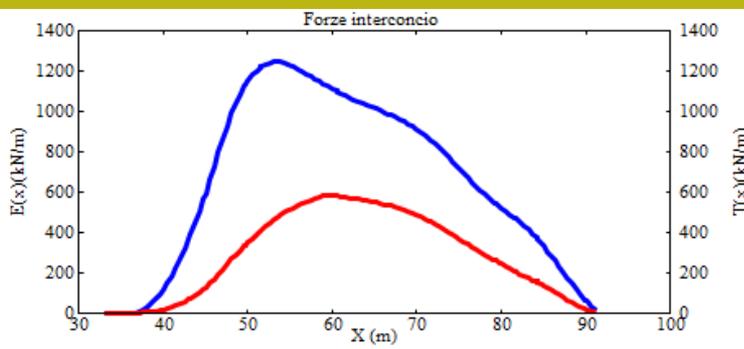


Distribución interna de las fuerzas de interacción , presiones y distribución local de Fs, localización índice **RHO** (verifica confiabilidad de la solución numérica encontrada). *grafic rendering por medio de GNU PLOT 4.6..(www.gnuplot.info)*



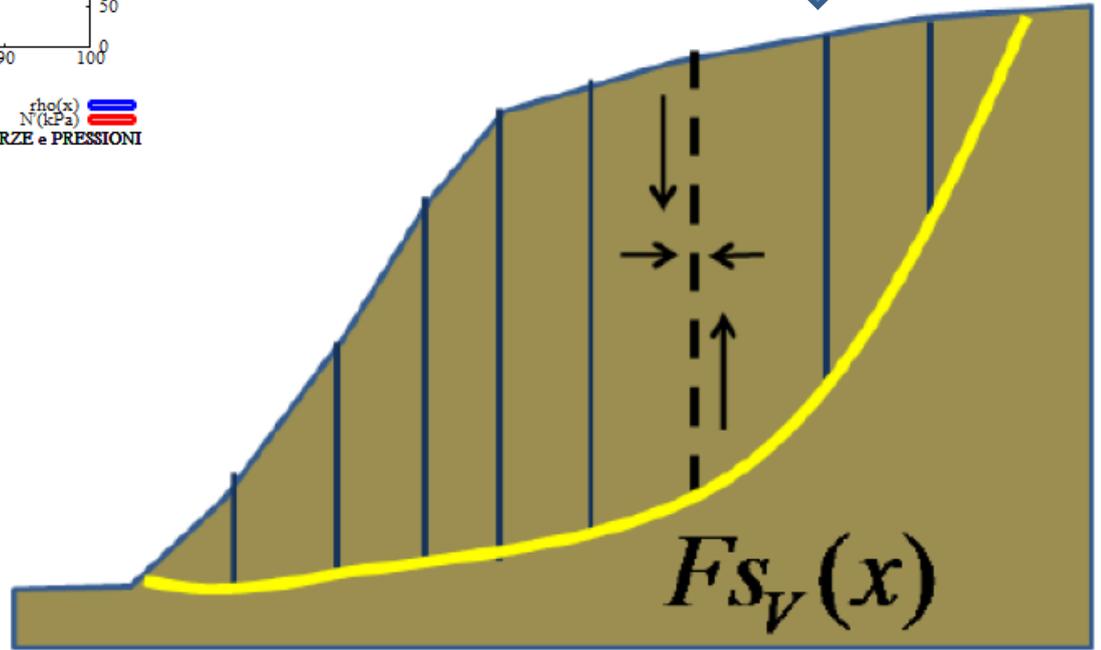
SSAP2010 (versione 4.1.3 2012) - DISTRIBUZIONE FORZE e PRESSIONI

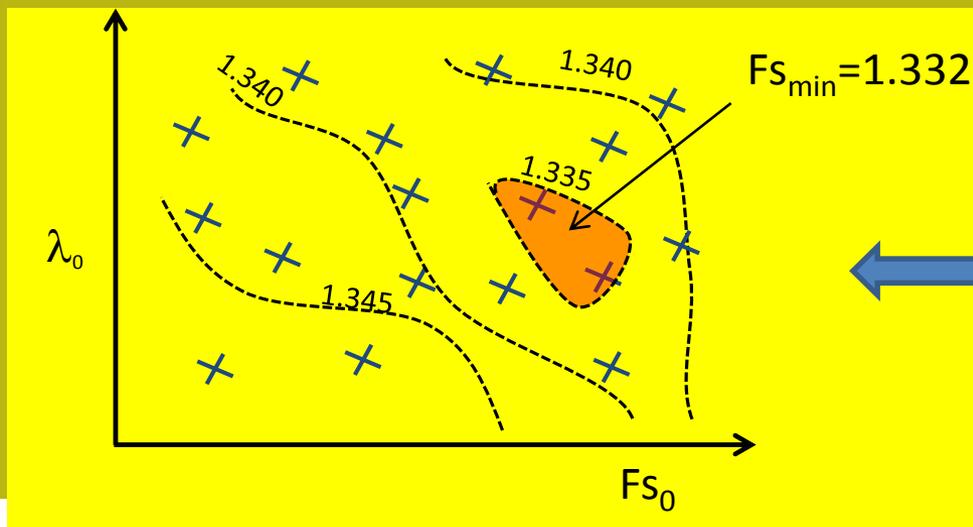
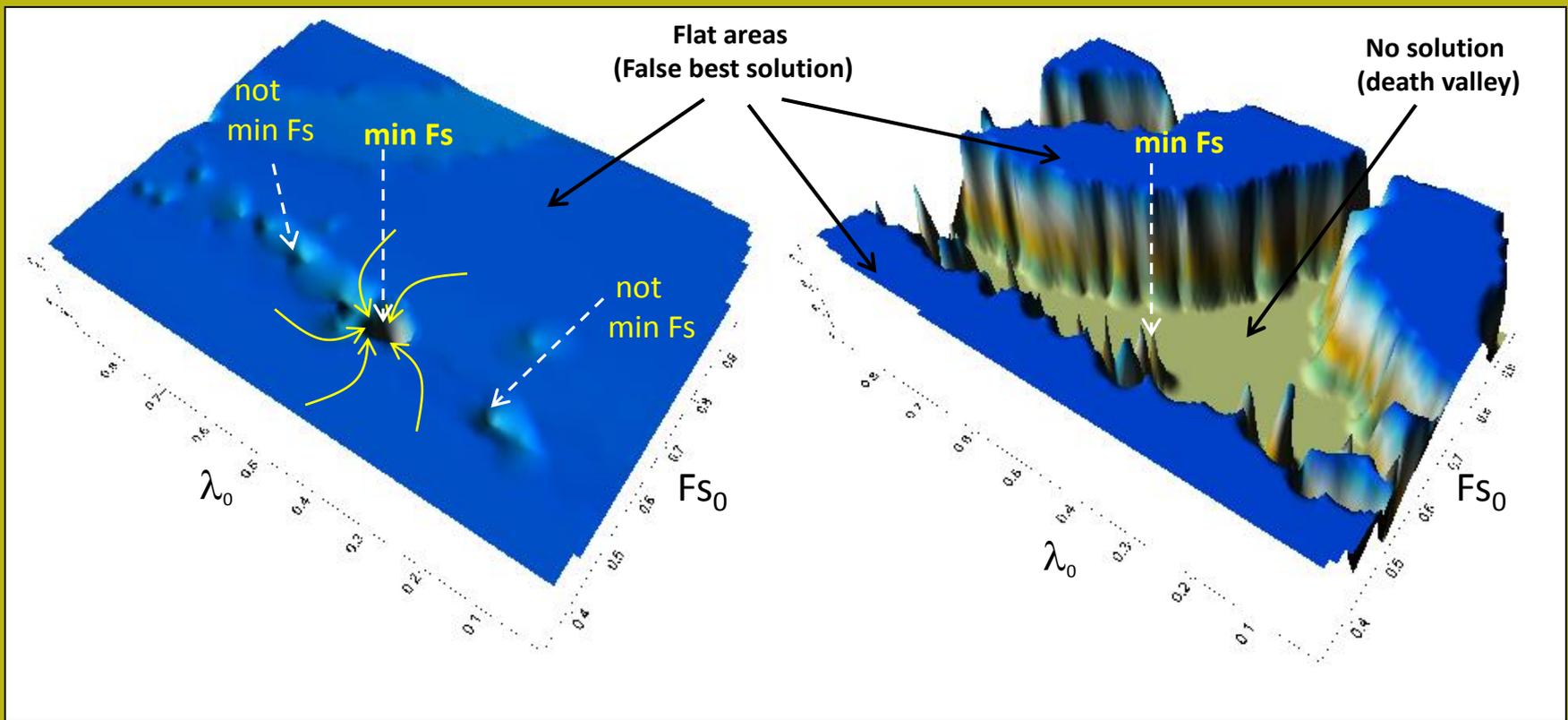
Mucho cuidado con calculo numérico y estabilidad numérica de las soluciones ...



SSAP2010 (versione 4.1.3 2012) - DISTRIBUZIONE FORZE e PRESSIONI

$$RHO(x) = \left| \frac{F_s}{F_{s_V}(x)} \right| < \psi$$





Uno de los varios problemas numéricos son también los parámetros iniciales para la búsqueda de la solución numérica de Fs . SSAP tiene 3 métodos originales para encontrare la mejor solución por el valor real de Fs través la **exploración del espacio** (λ_0, Fs_0)

Unos de estos método usa una implementación lel algoritmo genético de optimización global: **Diferencial evolución** (Storne y Price 1996)

Aplicación en Italia distrito minero de Carrara:

Talud con detritos residual de la extracción del mármol, muros de contención por terracería, con grandes bloques de mármol, substrato de macizo rocoso de buena calidad ..

SSAP 4.1.3 (2012) - Slope Stability Analysis Program
 Software by Dr.Geol. L.Borselli - www.lorenzo-borselli.eu
 SSAP/DXF generator rel. 1.0.4 (2012)

Data : 11/11/2012
 Localita' :
 Descrizione :
 n = No. strato o lente

Modello di calcolo : Morgenstern & Price (1965)

Parametri Geotecnici degli strati

N.	phi° deg	C° kPa	Cu kPa	Gamm kN/m3	GammSat kN/m3	sgci MPa	GSI	mi	D
1	38.00	10.00	0	21.00	22.00	0	0	0	0
2	0	0	0	24.00	25.00	100.00	50.00	10.00	0
3	0	0	0	23.50	24.00	100.00	20.00	10.00	0.50
4	0	0	0	23.50	24.00	100.00	20.00	10.00	0.50



DATI 10 SUP. CON MINOR Fs

Fs minimo : 0.797
 Range Fs : 0.797 0.855
 Differenza % Range Fs : 6.8
 Coefficiente Sismico orizzontale - Kh: 0.000

GENERAZIONE SUPERFICI RANDOM

Campione Superfici - N.: 1591
 Lunghezza media segmenti (m) : 2.0
 Range X inizio generazione : 10.0 - 55.0
 Range X termine generazione : 15.0 - 59.0
 Livello Y minimo considerato : 0.0

Evaluación de estabilidad en simulacro de formación de porción saturada en la base (en morado las 10 superficies con menor Fs encontrado) ..

Aplicación en Italia distrito minero de Carrara:

Talud con detritos residual de la extracción del mármol, muro de contención por terracería, con grandes bloques de mármol, substrato de macizo rocoso de buena calidad ..

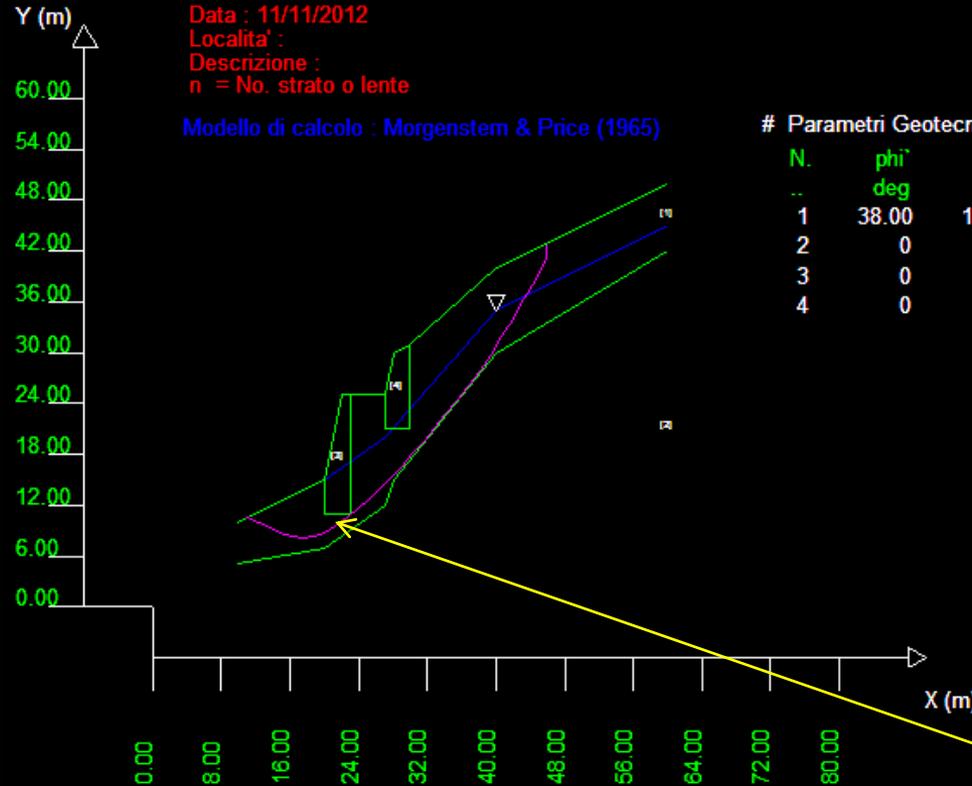
SSAP 4.1.3 (2012) - Slope Stability Analysis Program
Software by Dr.Geol. L.Borselli - www.lorenzo-borselli.eu
SSAP/DXF generator rel. 1.0.4 (2012)

Data : 11/11/2012
Localita' :
Descripción :
n = No. strato o lente

Modello di calcolo : Morgenstem & Price (1965)

Parametri Geotecnici degli strati

N.	phi'	C'	Cu	Gamm	GammSat	sgci	GSI	mi	D
--	deg	kPa	kPa	kN/m3	kN/m3	MPa	--	--	--
1	38.00	10.00	0	21.00	22.00	0	0	0	0
2	0	0	0	24.00	25.00	100.00	50.00	10.00	0
3	0	0	0	23.50	24.00	100.00	20.00	10.00	0.50
4	0	0	0	23.50	24.00	100.00	20.00	10.00	0.50



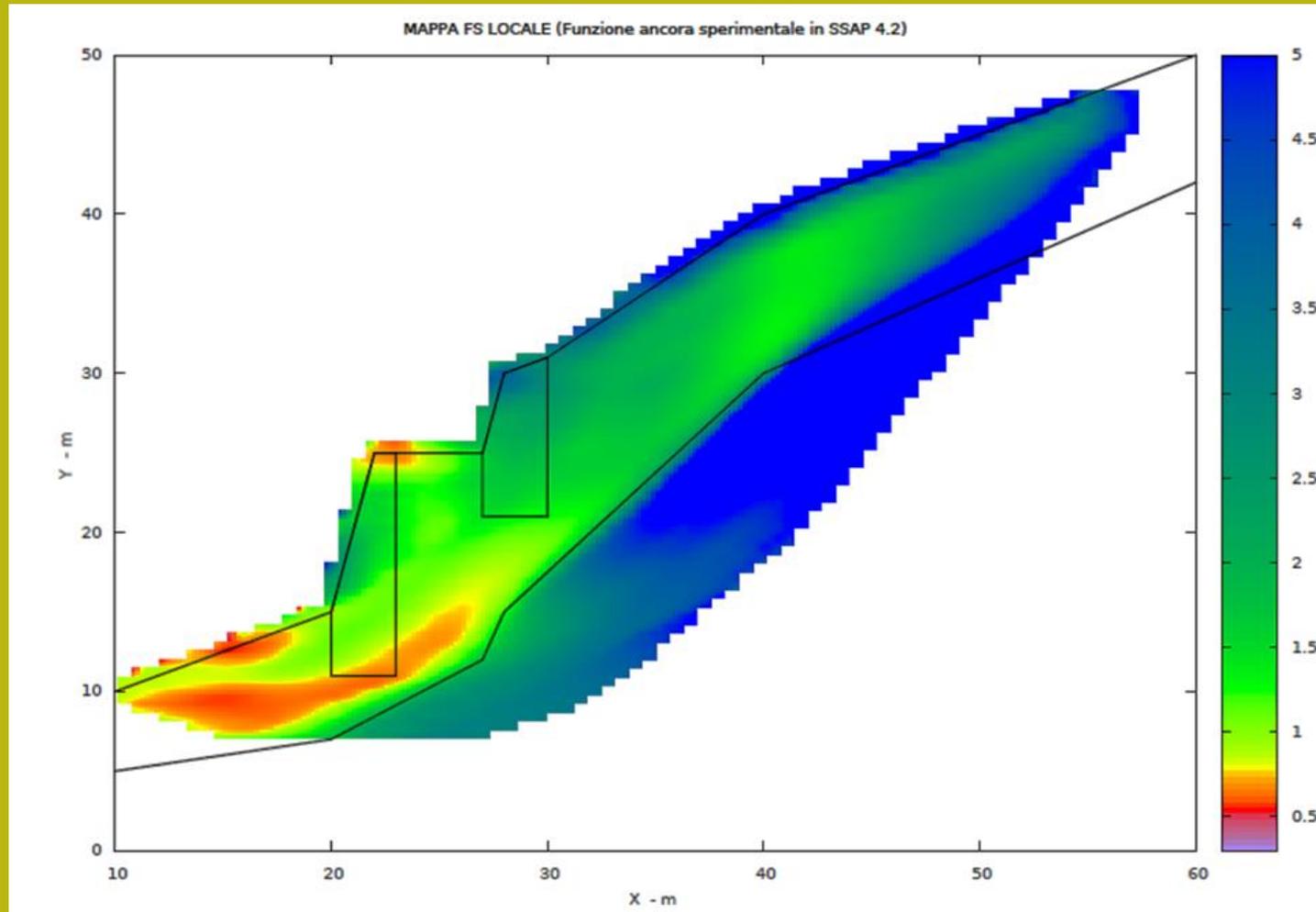
ANALISI SUPERFICIE SINGOLA
<< Risultato analisi >>

Fs : 0.797
Coefficiente Sismico Orizzontale Kh: 0.000
Coefficiente Sismico Critico (Fs=1) : 0.00000
Ea (kN/m) Forza destabilizzante di testa : 0.00
Eb (kN/m) Forza stabilizzante alla base : 0.00

Evaluación de estabilidad de simulacro de formación de porción saturada en la base (en morado la superficie con menor Fs encontrado ... se nota la non circularidad de la misma superficie ...)

Aplicación en Italia distrito minero de Carrara:

Talud con detritos residual de la extracción del mármol, muro de contención por terracería, con grandes bloques de mármol, substrato de macizo rocoso de buena calidad ..



2D color map with distribution of average local FOS obtained by local stress distribution (Borselli, 2012).

Nueva con la version 4.2.0 y en adelante

Aplicación en Italia :

Talud con sobrecarga de edificios y 3 líneas de palos de contención arriba tres niveles de arcillitas (olistostroma eocene) con diferente niveles de alteración ..

SSAP 4.1.3 (2012) - Slope Stability Analysis Program
 Software by Dr. Geol. L. Borselli - www.lorenzo-borselli.eu
 SSAP/DXF generator rel. 1.0.4 (2012)

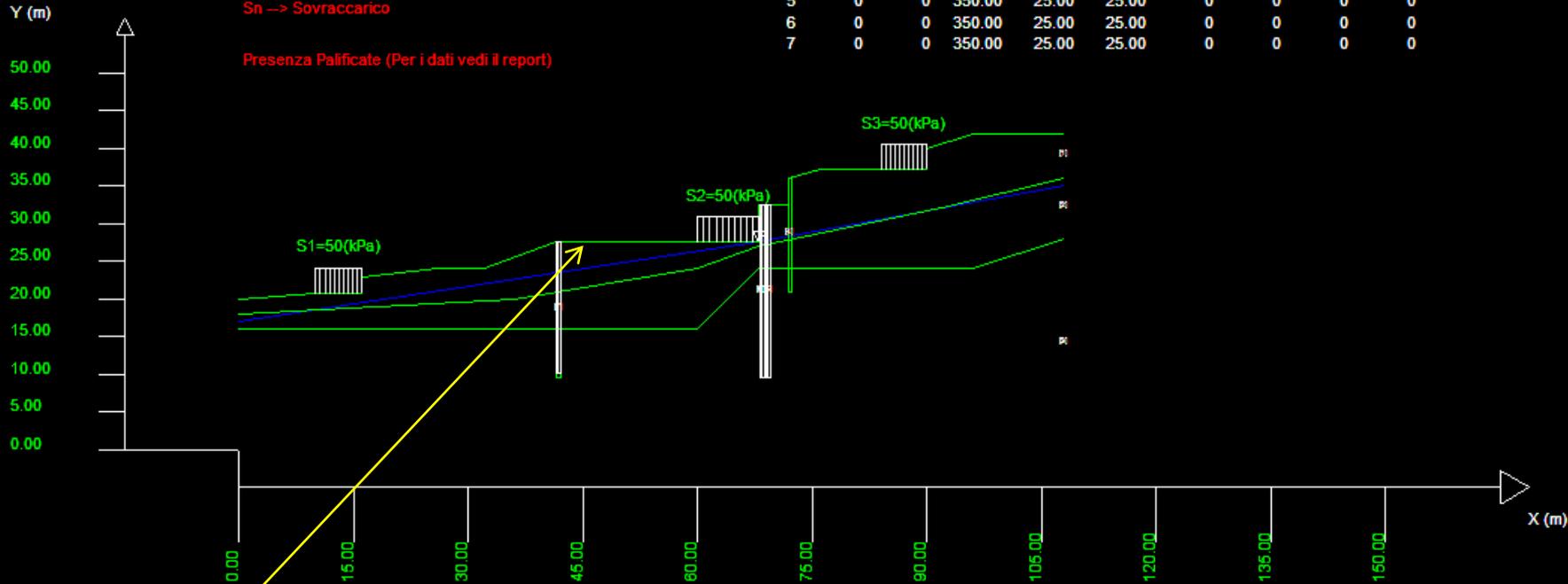
Data : 11/11/2012
 Localita' :
 Descripción :
 n = No. strato o lente

Sn -> Sovraccarico

Presenza Palificate (Per i dati vedi il report)

Parametri Geotecnici degli strati

N.	phi°	C°	Cu	Gamm	GammSat	sgci	GSI	mi	D
..	deg	kPa	kPa	kN/m3	kN/m3	MPa
1	16.00	2.00	0	16.50	18.00	0	0	0	0
2	21.00	5.00	0	17.50	18.50	0	0	0	0
3	26.00	10.00	0	18.50	19.00	0	0	0	0
4	0	0	1000.00	25.00	25.00	0	0	0	0
5	0	0	350.00	25.00	25.00	0	0	0	0
6	0	0	350.00	25.00	25.00	0	0	0	0
7	0	0	350.00	25.00	25.00	0	0	0	0



El estrato 1 es reconocido como un material de muy baja resistencia que constituye un cuerpo de un antiguo deslizamiento... las líneas de palos ofrecen una reacción horizontal al deslizamiento (metodo Ito e Matsui 1975-81 Hassiotis et al. 1997) y también son elementos resistente al corte (lentes con CU>0)

Aplicación en Italia :

Talud con sobrecarga de edificios y 3 líneas de palos de contención arriba tres niveles de arcillitas (olistostroma eocene) con diferente niveles de alteración ..

SSAP 4.1.3 (2012) - Slope Stability Analysis Program
Software by Dr.Geol. L.Borselli - www.lorenzo-borselli.eu
SSAP/DXF generator rel. 1.0.4 (2012)

Data : 11/11/2012
Localita' :
Descrizione :
n = No. strato o lente

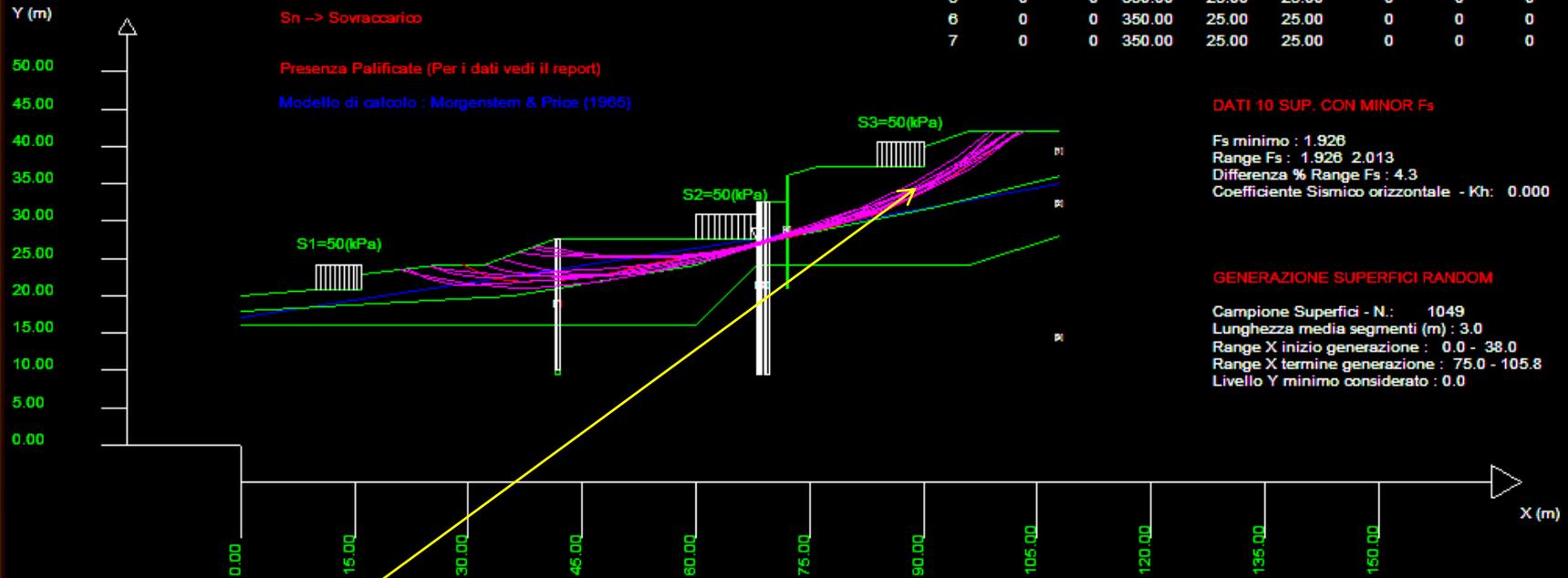
Sn -> Sovraccarico

Presenza Palificate (Per i dati vedi il report)

Modello di calcolo : Morgenstem & Price (1965)

Parametri Geotecnici degli strati

N.	phi'	C'	Cu	Gamm	GammSat	sgci	GSI	mi	D
..	deg	kPa	kPa	kN/m3	kN/m3	MPa
1	16.00	2.00	0	16.50	18.00	0	0	0	0
2	21.00	5.00	0	17.50	18.50	0	0	0	0
3	26.00	10.00	0	18.50	19.00	0	0	0	0
4	0	0	1000.00	25.00	25.00	0	0	0	0
5	0	0	350.00	25.00	25.00	0	0	0	0
6	0	0	350.00	25.00	25.00	0	0	0	0
7	0	0	350.00	25.00	25.00	0	0	0	0



Evaluación de estabilidad con motor de generación superficies: SNIFF-RANDOM-SEARCH (en morado las 10 superficies con menor Fs encontrado) ..

Aplicación en Italia :

Talud con sobrecarga de edificios y 3 líneas de palos de contención arriba tres niveles de arcillitas (olistostroma eocene) con diferente niveles de alteración ..

SSAP 4.1.3 (2012) - Slope Stability Analysis Program
Software by Dr. Geol. L. Borselli - www.lorenzo-borselli.eu
SSAP/DXF generator rel. 1.0.4 (2012)

Data : 11/11/2012
Localita' :
Descripción :
n = No. strato o lente

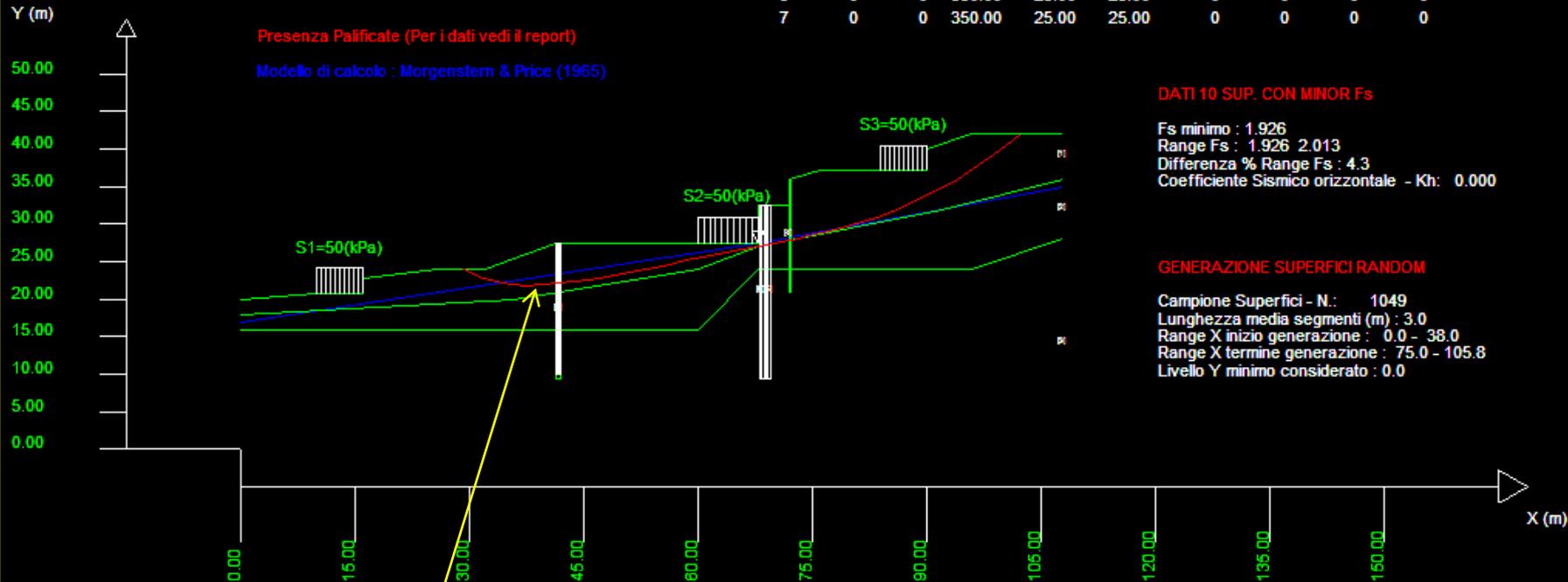
Sn -> Sovraccarico

Presenza Palificate (Per i dati vedi il report)

Modello di calcolo : Morgenstern & Price (1965)

Parametri Geotecnici degli strati

N.	phi ⁱ deg	C ⁱ kPa	Cu kPa	Gamm kN/m3	GammSat kN/m3	sgci MPa	GSI	mi	D
1	16.00	2.00	0	16.50	18.00	0	0	0	0
2	21.00	5.00	0	17.50	18.50	0	0	0	0
3	26.00	10.00	0	18.50	19.00	0	0	0	0
4	0	0	1000.00	25.00	25.00	0	0	0	0
5	0	0	350.00	25.00	25.00	0	0	0	0
6	0	0	350.00	25.00	25.00	0	0	0	0
7	0	0	350.00	25.00	25.00	0	0	0	0



Evaluación de estabilidad (en morado la superficie con menor Fs encontrado ... se nota la **non circularidad** de la misma superficie ...)

EXAMPLES: Earth dam stability check ^{Draft}

This example is related to a stability check requested by a SSAP User on a Earth dam of a small reservoir.



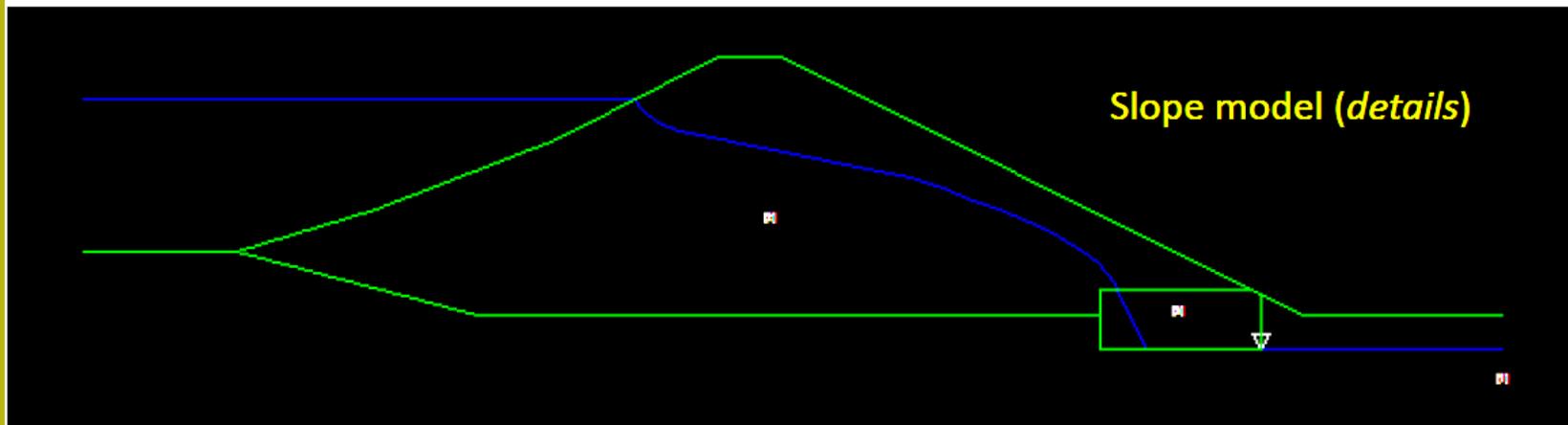
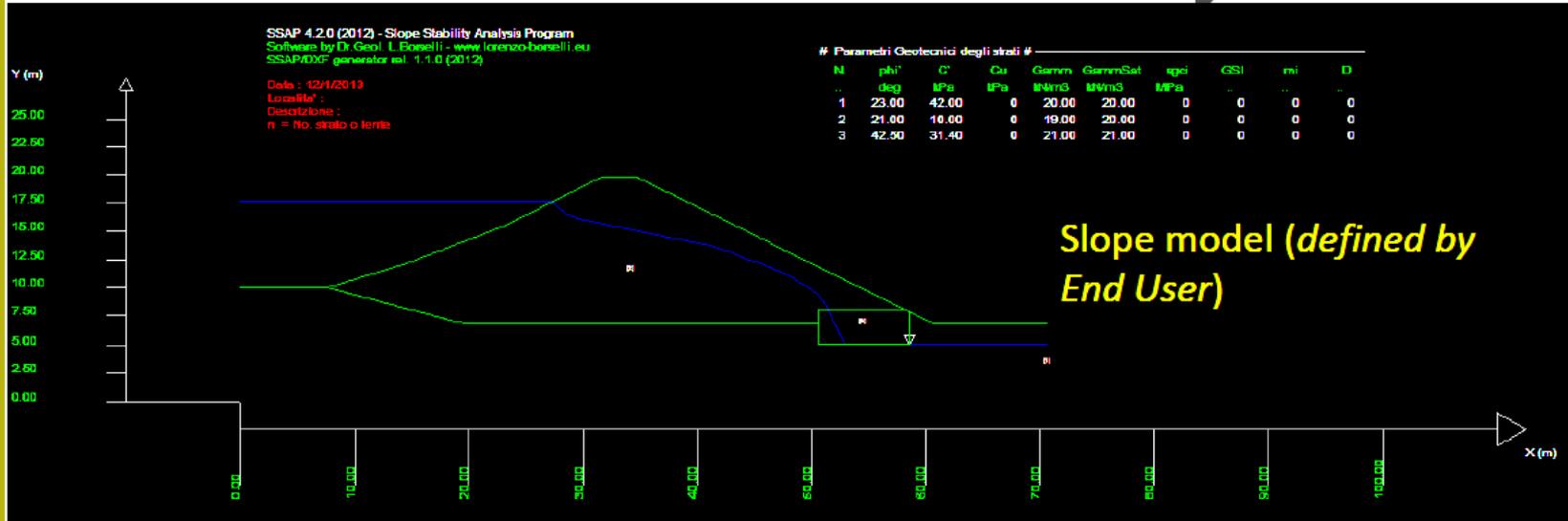
**Reservoir (anti.mod)
verified by L Borselli (2012)**

Earth dam build at end of 50s
Problems of settlement and
deformation of earth fill since 2000
Substratum marine Pliocene clays
Central Tuscany



<http://www.lorenzo-borselli.eu>

EXAMPLES: Earth dam stability check



EXAMPLES: Earth dam stability check

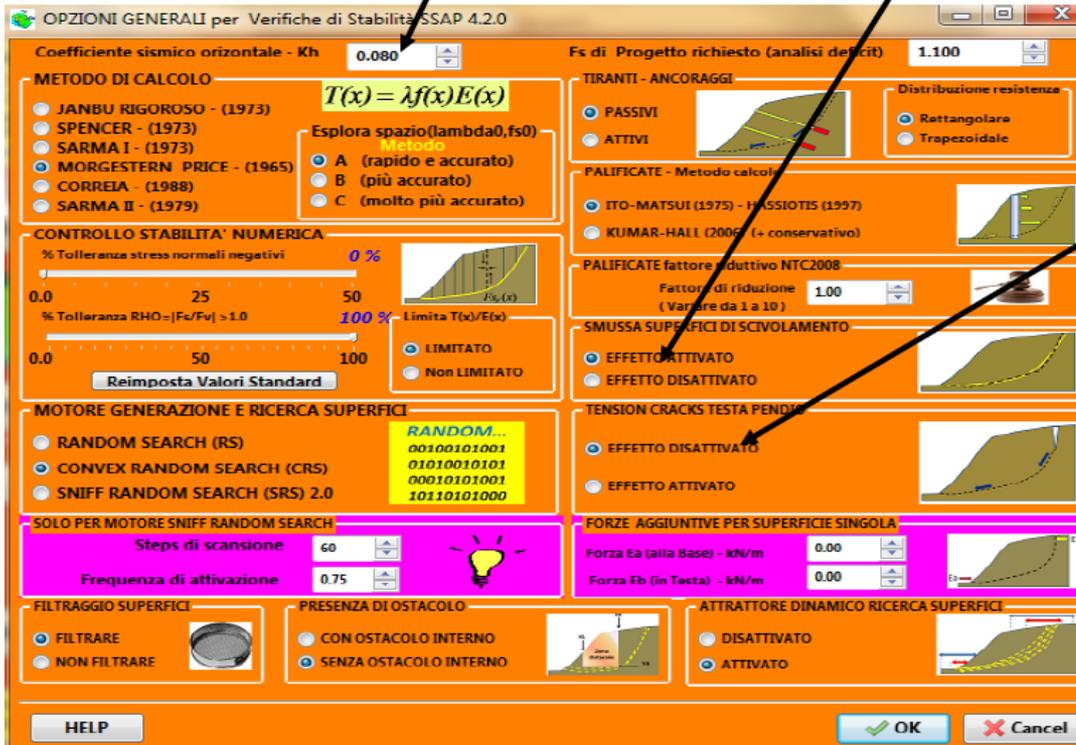
Draft

Options activated before global slope stability verification run.

Activated options in SSSAP 4.2.0

Horizontal seismic coefficient

Sliding surfaces smoothing



Tension crack Effect: deactivated (optional)

EXAMPLES: Earth dam stability check ^{Draft}

Considered scenario Analysis in the slope stability verification.

Scenario analysis starting with maximum water level in the reservoir:

1) Long term drained conditions

- A. Without rapid drawdown
- B. With rapid drawdown (very low probability)

2) Undrained condition (short terms)

- A. No rapid drawdown
- B. With rapid drawdown

In all the case horizontal seismic pseudostatic coefficients

$K_h=0.08$, $K_v=0.04$

<http://www.lorenzo-borselli.eu>

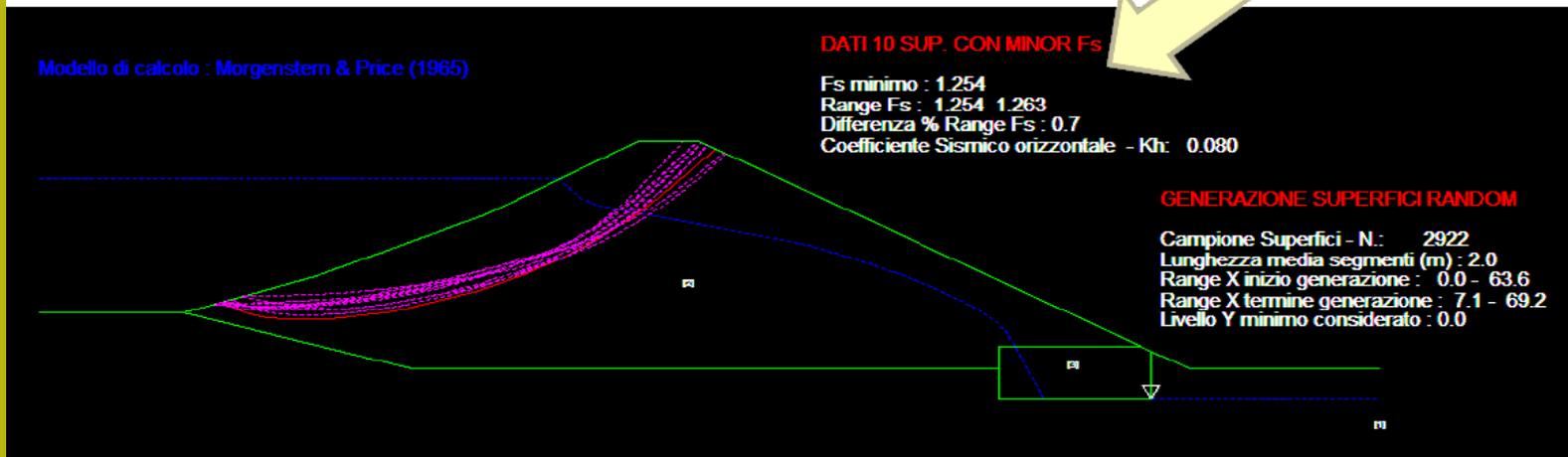
EXAMPLES: Earth dam stability check

Results of scenario analysis

1.A Long term drained condition (max. Water level)

$K_h=0.08$

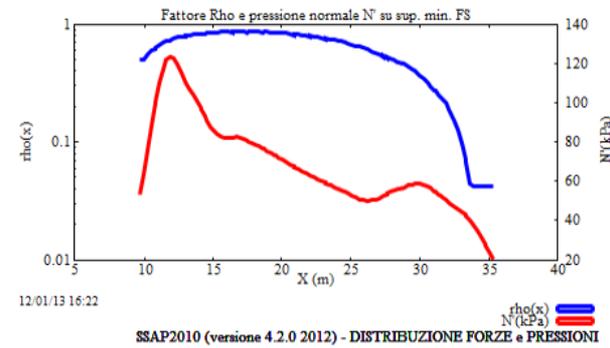
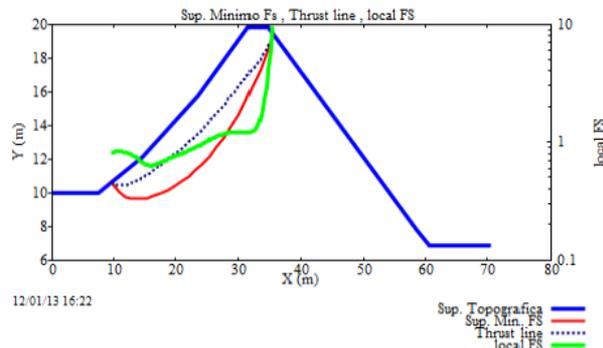
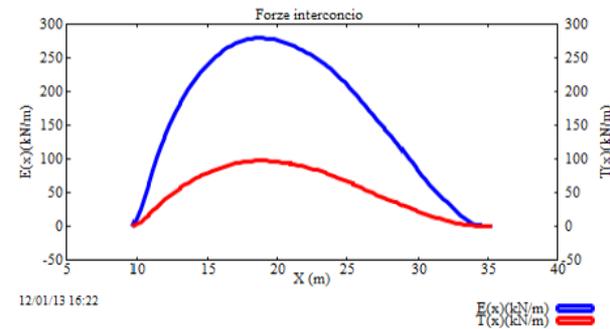
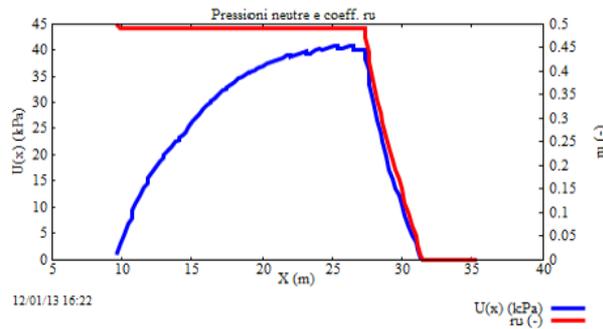
$F_s = 1.254$



EXAMPLES: Earth dam stability check Draft

Results of scenario analysis

Forces and pressure diagrams related to the most critical sliding surface



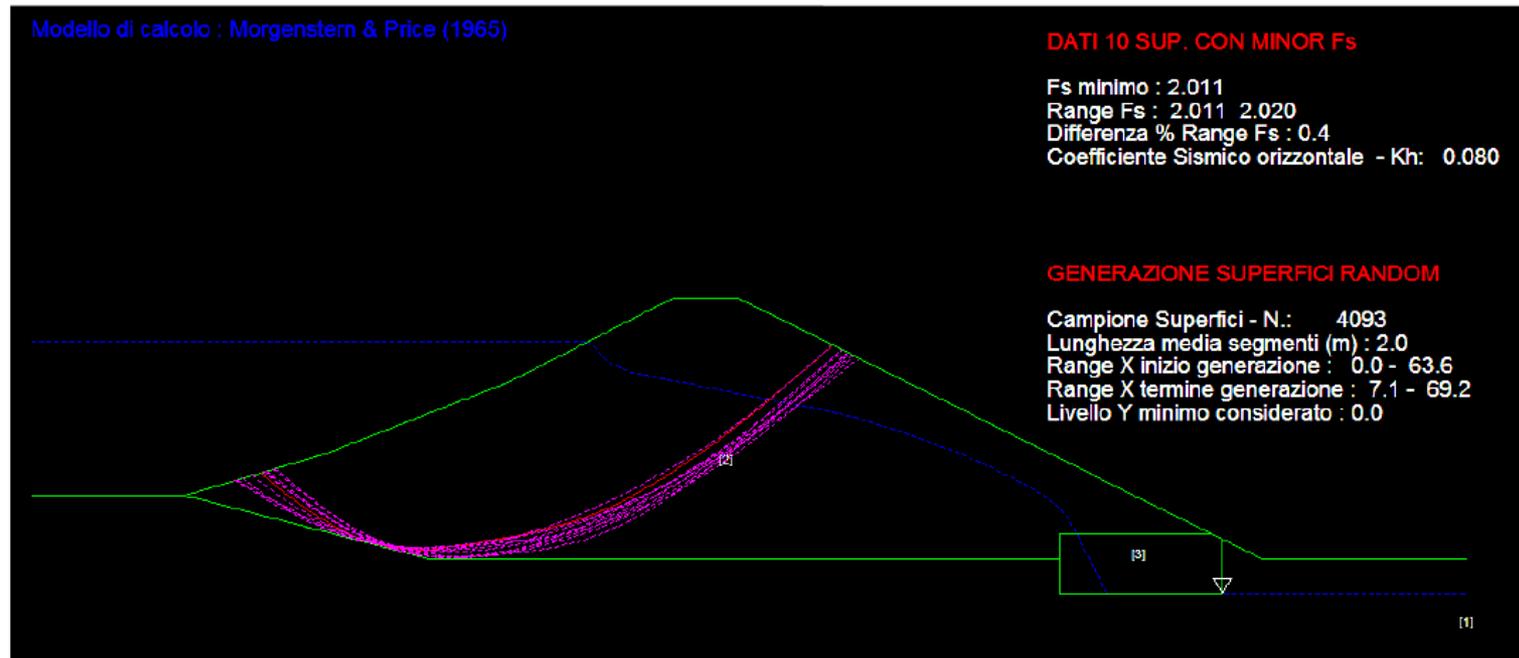
<http://www.lorenzo-borselli.eu>

EXAMPLES: Earth dam stability check *Draft*

Results of scenario analysis

2.B Undrained (short term) conditions (also the most appropriate to verify seismic effects)
Activated rapid drawdown effects (eliminating positive effect of water surcharge of submerged slope)

$$F_s = 2.011 \text{ with } kh=0.08$$



EXAMPLES: Earth dam stability check *Draft*

Results of scenario analysis

Long term
drained
conditions
under max.
Water level
Fs=1.235

# Parametri Geotecnici degli strati #					
N.	phi` deg	C` kPa	Cu kPa	Gamm kN/m3	GammSat kN/m3
1	23.00	42.00	0	20.00	20.00
2	21.00	10.00	0	19.00	20.00
3	42.50	31.40	0	21.00	21.00

Short terms
Undrained cond.
Under rapid
drawdown
FS=2.0

# Parametri Geotecnici degli strati #					
N.	phi` deg	C` kPa	Cu kPa	Gamm kN/m3	GammSat kN/m3
1	0	0	221.00	20.00	20.00
2	0	0	65.00	19.00	20.00
3	0	0	300.00	21.00	21.00

The final result is conditioned from the very high CU values of stratum 2 compared to c' e phi' values of drained conditions

Using for stratum 2 CU= 35 kPa
The final results became FS=1.1

BACK ANALYSIS OF TEZIUTLAN (PUEBLA, MEXICO) LANDSLIDES, OCCURRED DURING THE 4-5TH OCTOBER 1999 EXTREME EVENT *

L.Borselli⁽¹⁾ D.Sarocchi⁽²⁾

L.Capra⁽³⁾ J.Lugo Hupb⁽³⁾



⁽¹⁾Consiglio Nazionale delle Ricerche - Istituto di Ricerca per la Protezione Idrogeologica (CNR-IRPI), Piazzale delle Cascine 15, 50144, Firenze, Italy, borselli@irpi.cnr.it (corresponding author).

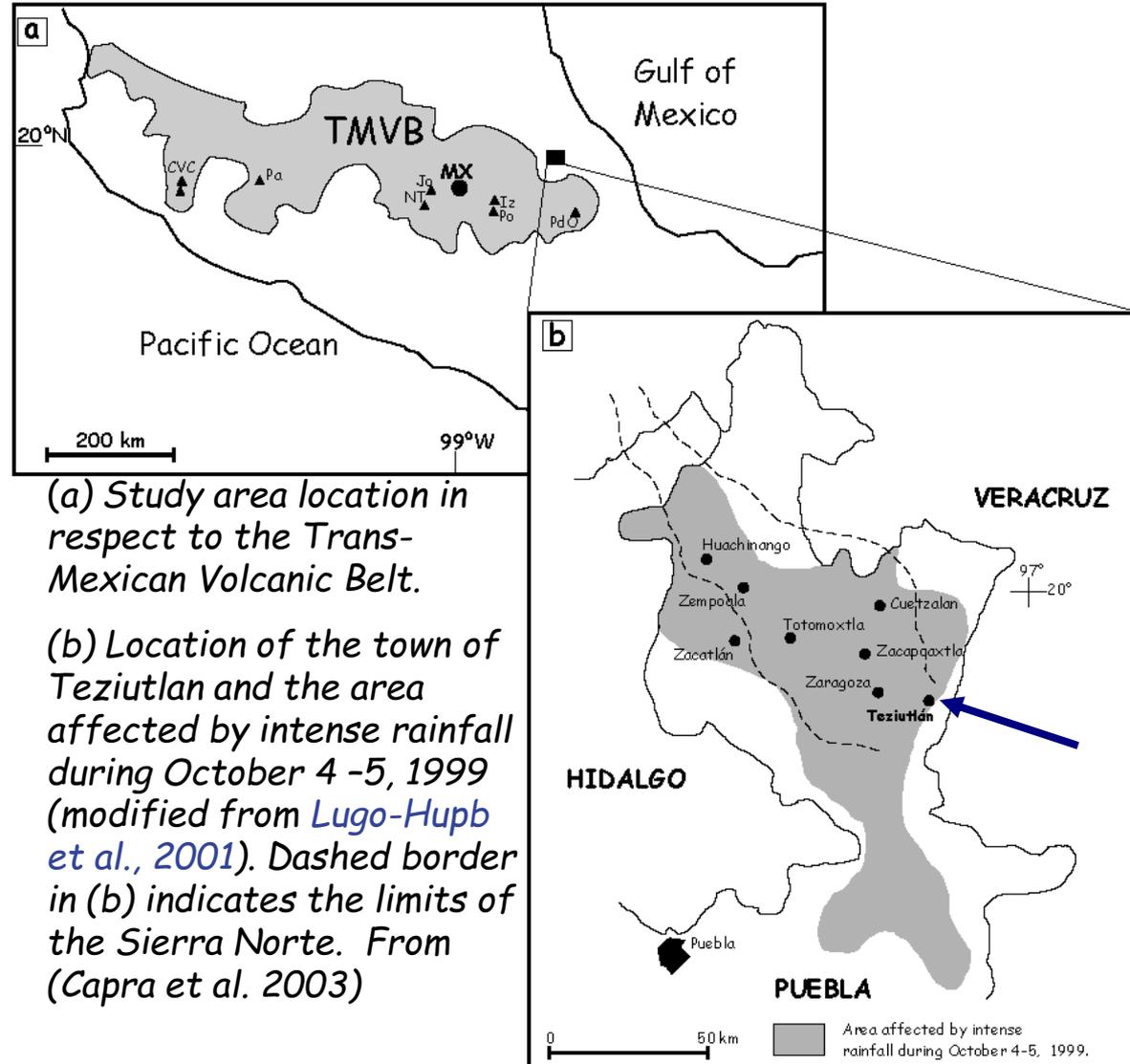
⁽²⁾Instituto de Geofisica, Universidad Nacional Autonoma de Mexico, Circuito Exterior; Ciudad Universitaria, Mexico City, Mexico.

⁽³⁾Instituto de Geografia, Universidad Nacional Autonoma de Mexico, Circuito Exterior; Ciudad Universitaria, Mexico City, Mexico.

* research under the support of the CNR- CONACYT agreement (2002-2004)

The Teziutlan area:

Teziutlan is located on top of a plateau at an elevation of 1900 m a.s.l. surrounded by relief that reaches up to 2800 m a.s.l.



(a) Study area location in respect to the Trans-Mexican Volcanic Belt.

(b) Location of the town of Teziutlan and the area affected by intense rainfall during October 4 -5, 1999 (modified from [Lugo-Hupb et al., 2001](#)). Dashed border in (b) indicates the limits of the Sierra Norte. From ([Capra et al. 2003](#))

Teziutlan cemetery:

Reconstruction of the event by
Information from direct witnesses.

Classification of the
Landslide as a *FLOW SLIDE*.

10 A.M. of 5 oct. 1999

Two phases:

1st: rotational landslide at the top of the slope. Modest soil mass formed by soil and resulting material due to tombs excavation and demolitions works in the cemetery (old tombs).

The landslide accumulate temporarily along the slope and surcharge it.

2nd : flow of a larger soil mass + small houses.
High speed and a run out of approx 100 m .
Witness report a sort of nebulized water sprayed out of the soil during the event. High velocity class 6-7 -following IUGS(1995) criteria.



Phase 1 – Rotational Landslide at top of the Hill

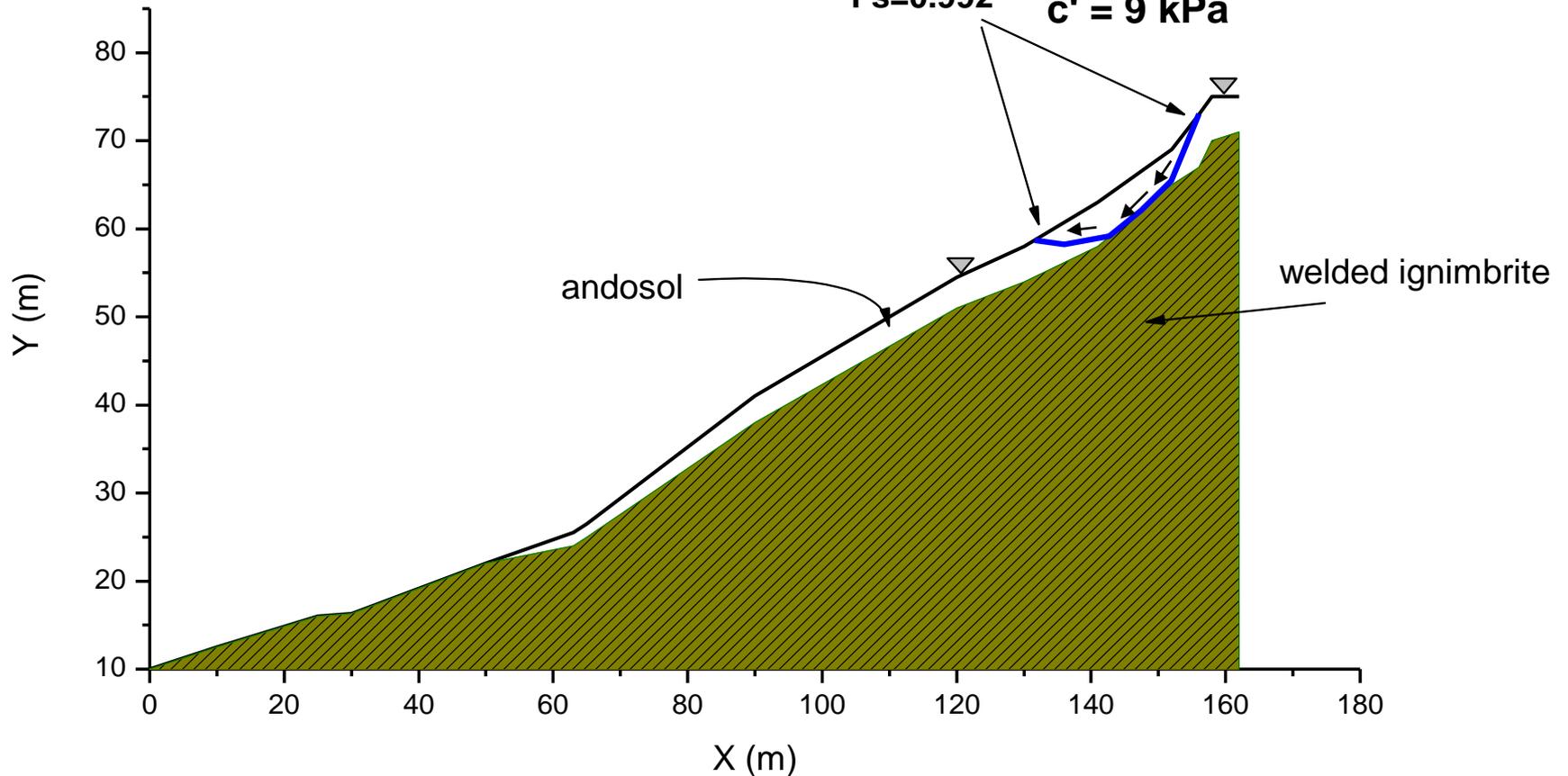
Teziutlàn Cemetery flow slide Phase 1 - Rotational Landslide

approx. volume 1500 m³

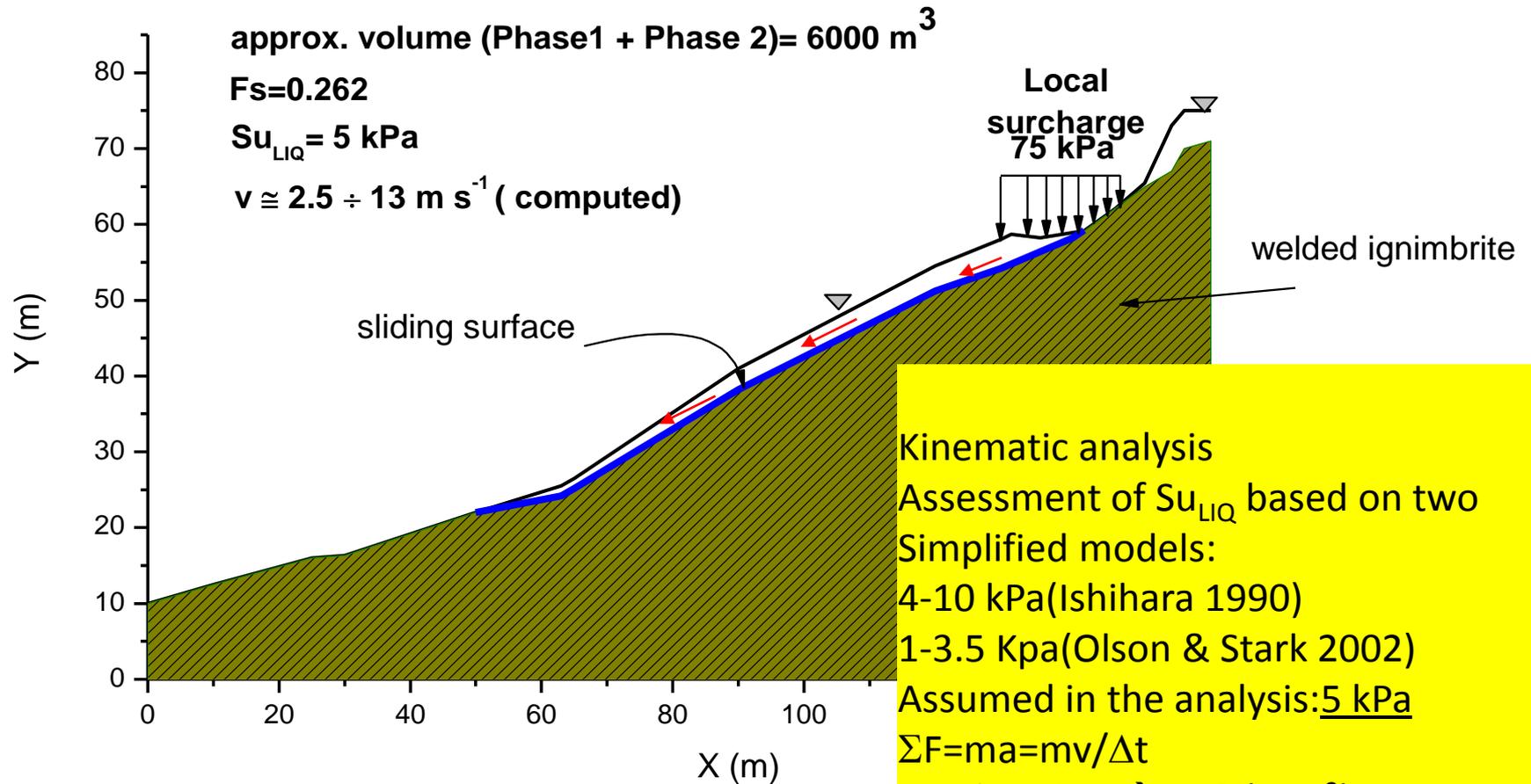
$\phi' = 34^\circ$

$c' = 9$ kPa

$F_s = 0.992$



Teziutlàn Cemetery flow slide Phase 2 - FLOW SLIDE



Kinematic analysis
Assessment of Su_{LIQ} based on two
Simplified models:
4-10 kPa(Ishihara 1990)
1-3.5 Kpa(Olson & Stark 2002)
Assumed in the analysis: 5 kPa
 $\Sigma F=ma=mv/\Delta t$
acceleration $\rightarrow a=3$ (m s⁻²)

LANDSLIDES IN TEZIUTLAN AREA

Previous studies on the 4-5 oct.1999 event:

L. Capra, J. Lugo-Hubp, L. Borselli (2003). Mass movements in tropical volcanic terrains: the case of Teziutlán (México). *Engineering Geology*. 68(3-4):359-379. "

Flores, P. y Alcántara Ayala, I. (2002) Cartografía morfogenética e identificación de procesos de ladera en Teziutlán, Puebla. *Investigaciones Geográficas, Boletín del Instituto de Geografía de la UNAM*, 49: 7-26.

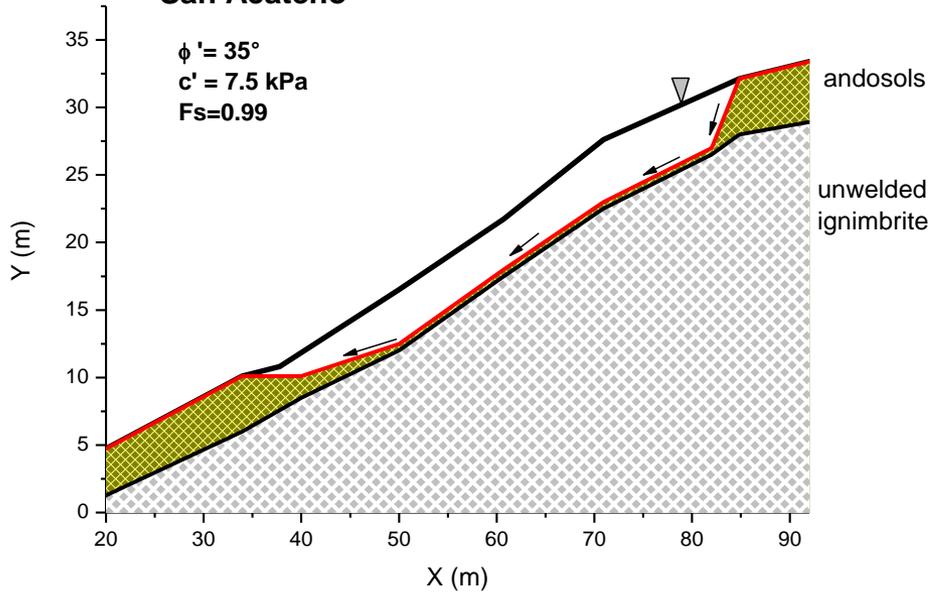
LANDSLIDES MAPPING AND CLASSIFICATION :

Based on more than 3000 landslides in the Sierra Norte de Puebla

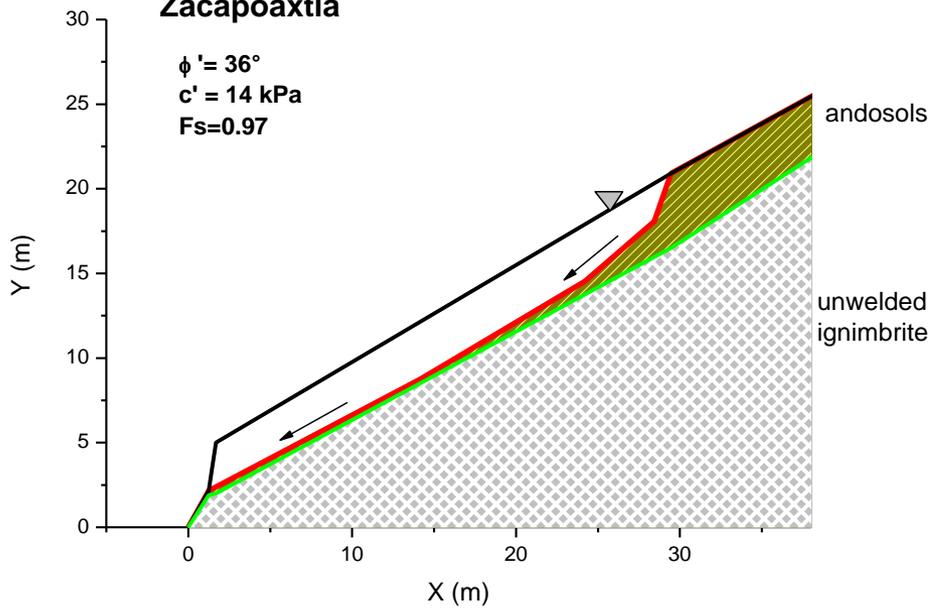
Type 1: superficial mass movements on unwelded ignimbrite sequence, forming small detrital fans at the base of steeper slopes.

Type 2: soil slide/debris flow from the remobilization of a volcanic sequence composed of paleosols interbedded with ashfall horizons. The paleosols (andosols) favored the formation of perched water tables on a hydraulic aquiclude (welded ignimbrite). Increase of positive pore-water pressures triggered the failure.

San Acateno



Zacapoxtla



Ranges for strength parameters for soils of Teziutlan area. They are valid for computation of effective shear strength at saturated condition.

Mass movements:

Type 1

γ_{sat} (kN/m ³)	ϕ'	c' (kPa)
16-17	36°-38°	4-11

Type 2

γ_{sat} (kN/m ³)	ϕ'	c' (kPa)
18-19	34°-36°	7.5-14

Shear Strength at liquefaction (e.g. case Flow Slide at Teziutlan cemetery)

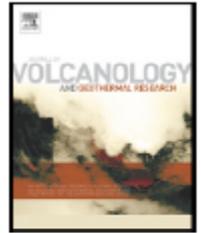
γ_{sat} (kN/m ³)	Su_{LIQ} (kPa)
18	3-5



Contents lists available at SciVerse ScienceDirect

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journal homepage: www.elsevier.com/locate/jvolgeores



Flank collapse scenarios at Volcán de Colima, Mexico: A relative instability analysis

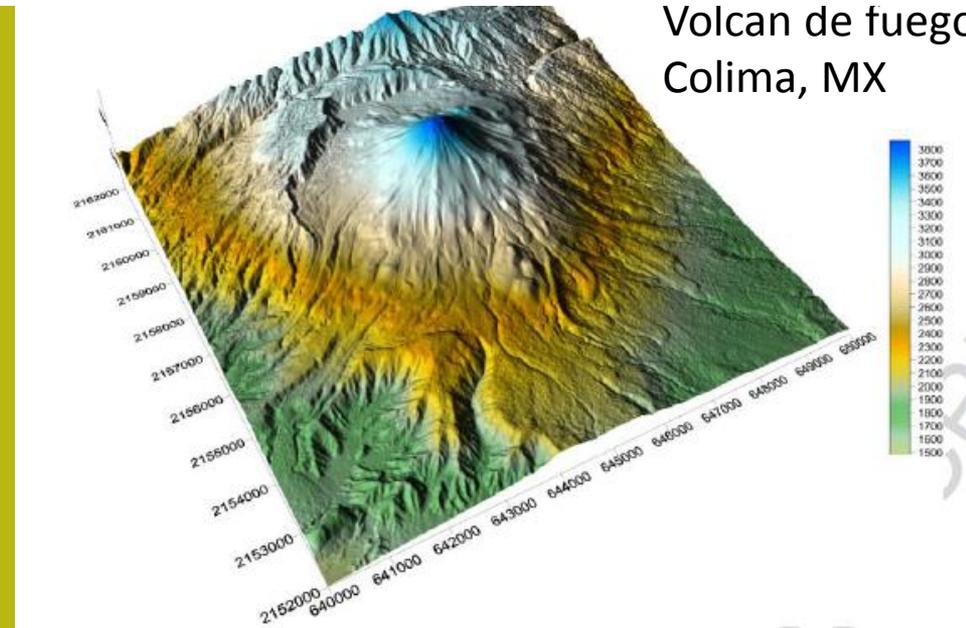
Lorenzo Borselli ^{a,*}, Lucia Capra ^b, Damiano Sarocchi ^a, Servando De la Cruz-Reyna ^c

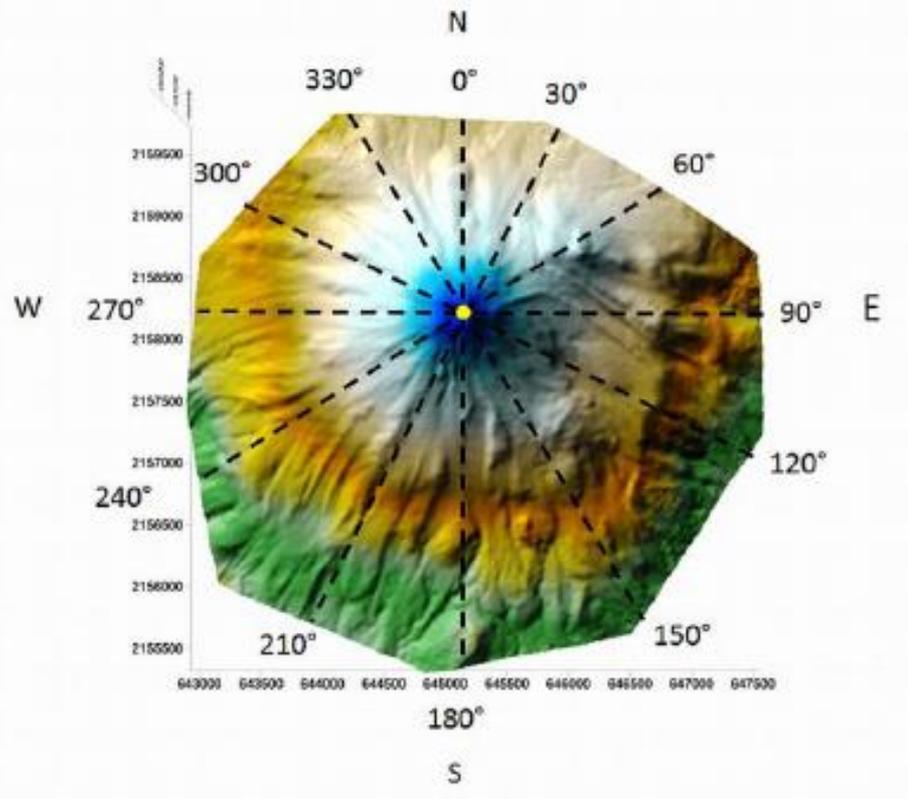
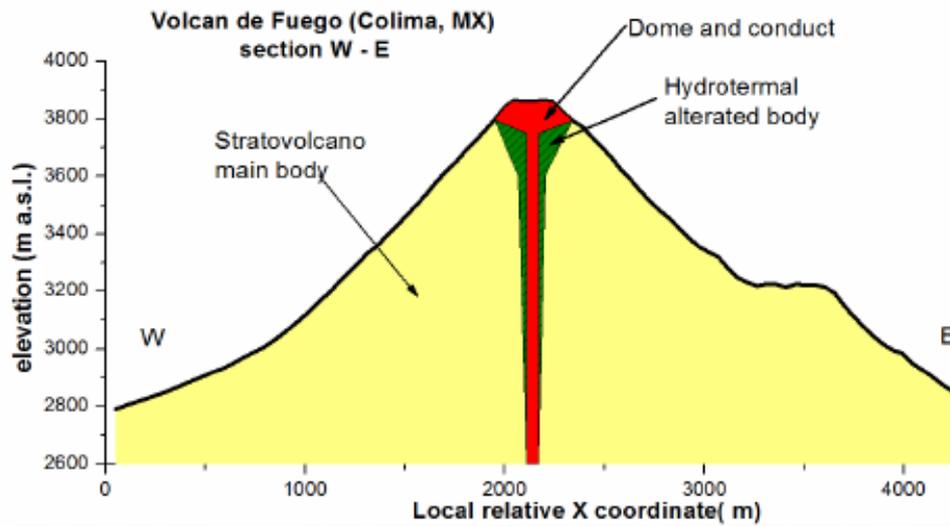
^a Instituto de Geología/ Fac. de Ingeniería - Universidad Autónoma de San Luis Potosí-UASLP, Av. Dr. Manuel Nava 5, C.P. 78240 San Luis Potosí, Mexico

^b Centro de Geociencias, UNAM, Campus Juriquilla, 76230 Queretaro, Mexico

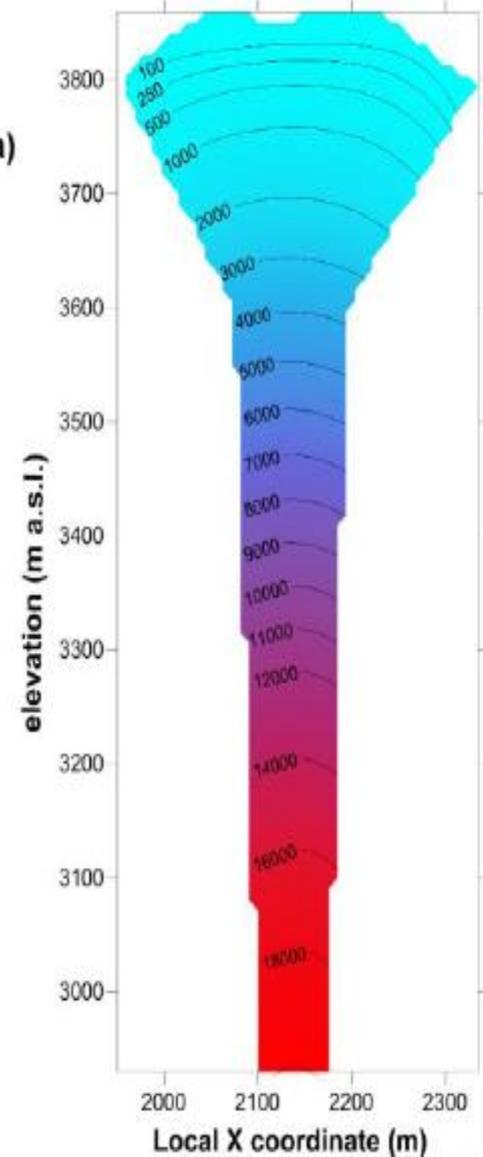
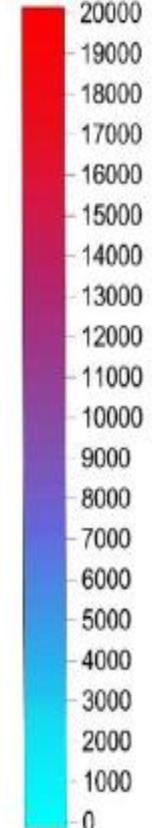
^c Departamento de Vulcanología, Instituto de Geofísica, Universidad Nacional Autónoma de México, Coyoacán 04510, D.F., Mexico

**Aplicación de SSAP 2010
En estudio de estabilidad
de los sectores del Volcan de fuego
Colima (2011)**

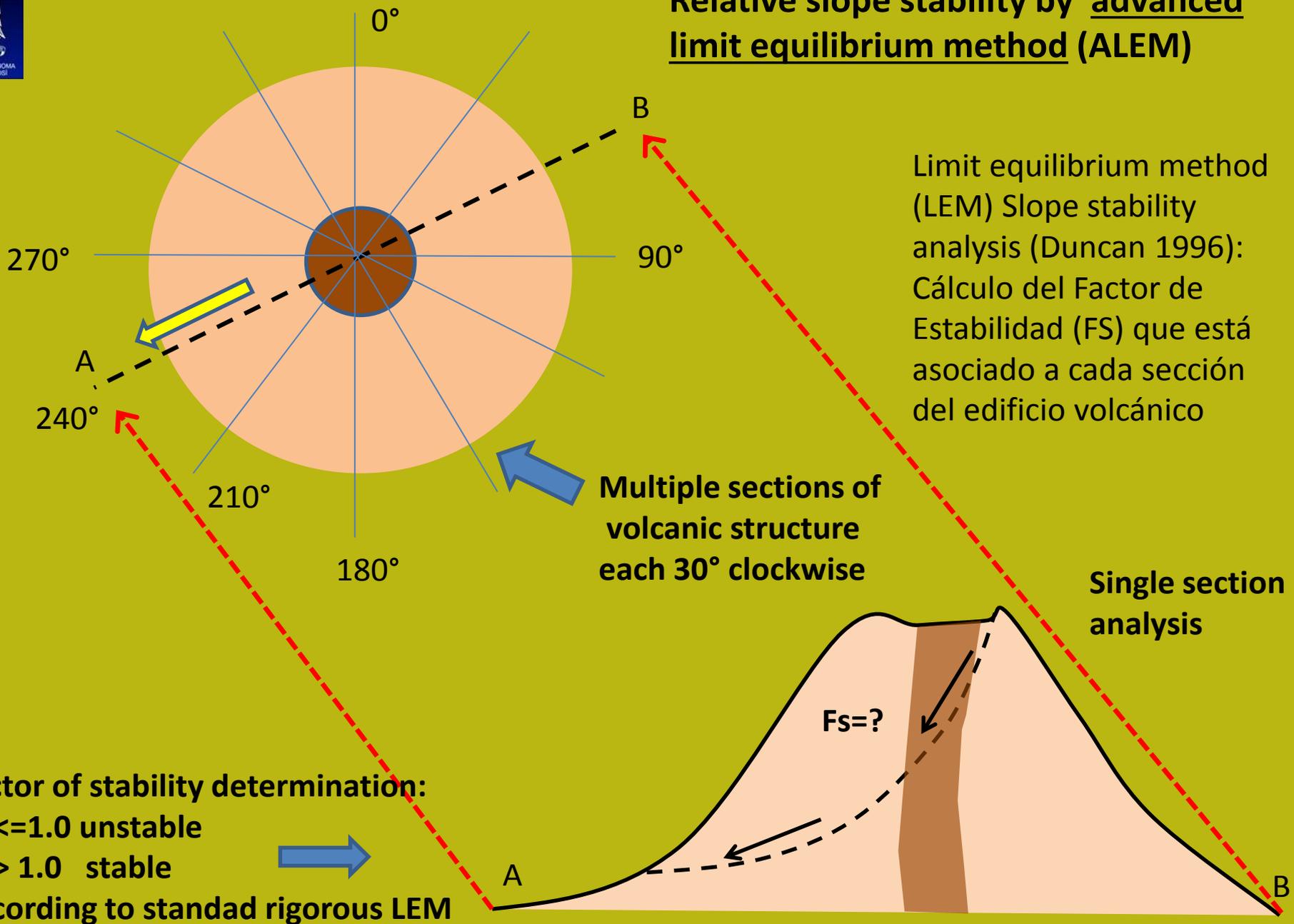




Fluid pressure (kPa)



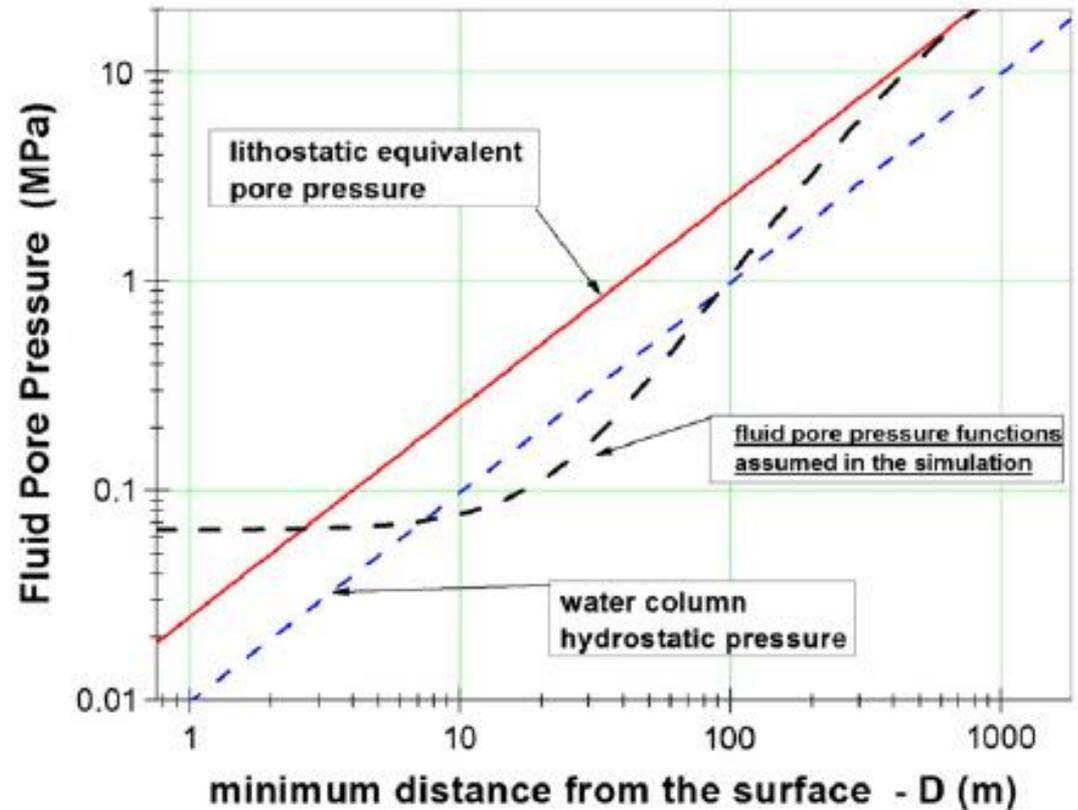
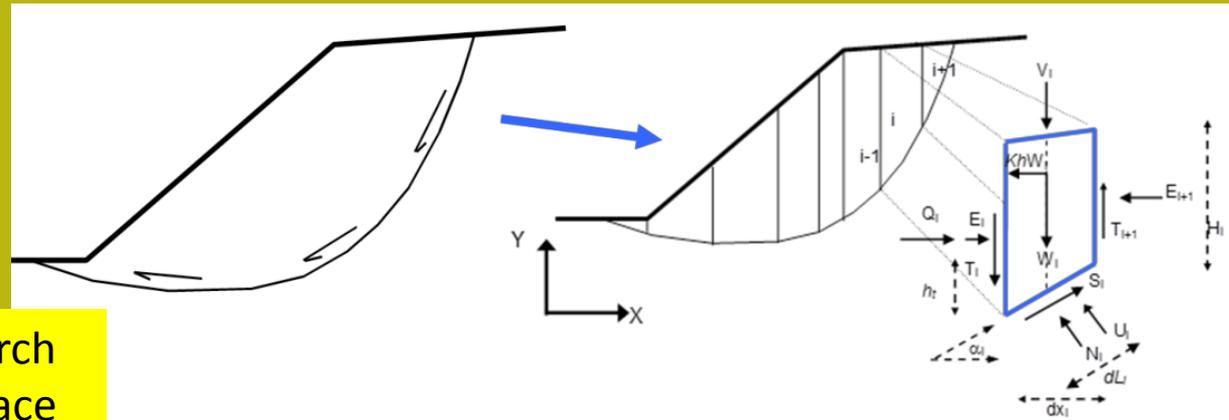
Relative slope stability by advanced limit equilibrium method (ALEM)



- Generic shape random search of minimum FS sliding surface by Monte Carlo method
- Rock mass strength criterion (Hoek et al. 2002,2006).
- Fluid pressure function (overpressure and dissipation fields Inside volcanic edifice) (Borselli et al. 2011)

$$\sigma_f = \gamma_w z F_D + U_{0_{MIN}}$$

$$F_D = 1 - Ae^{-kD}$$

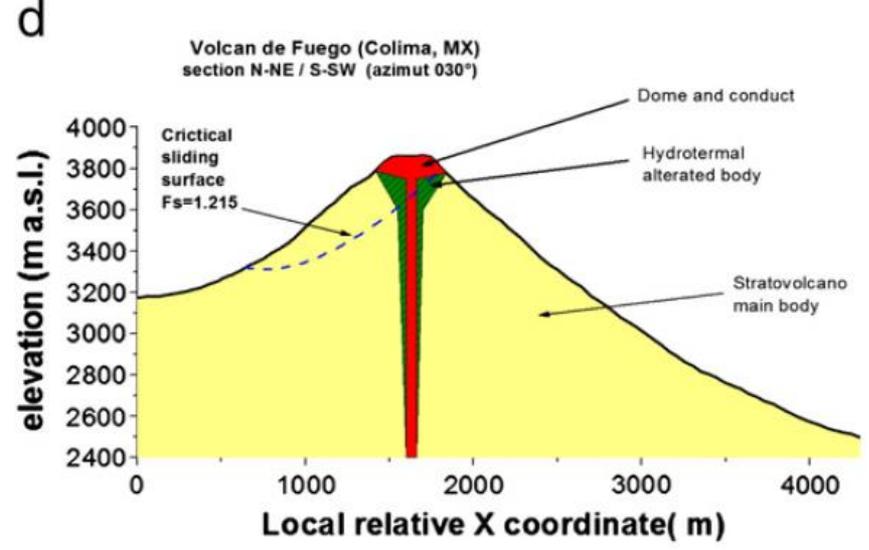
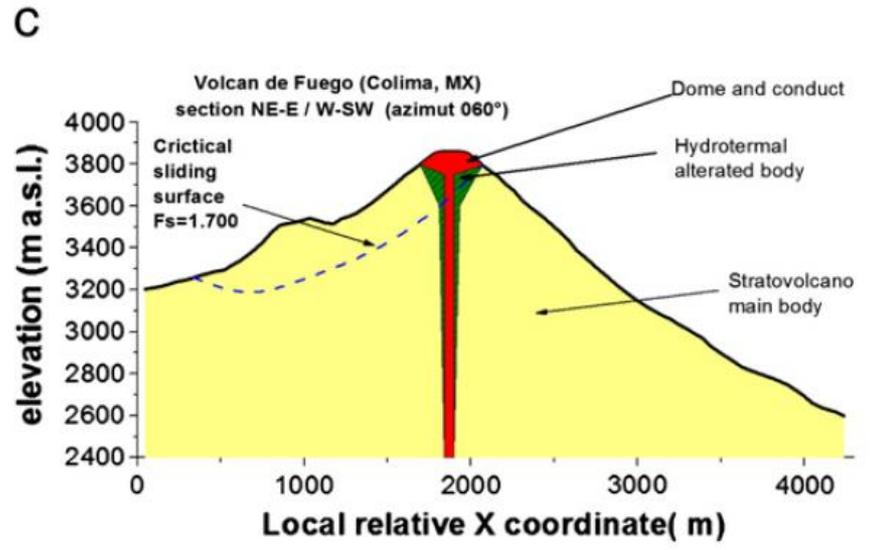
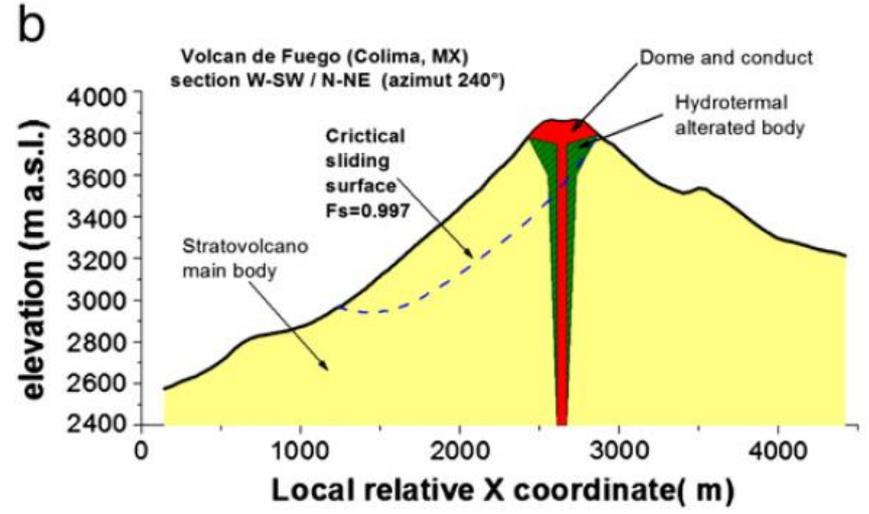
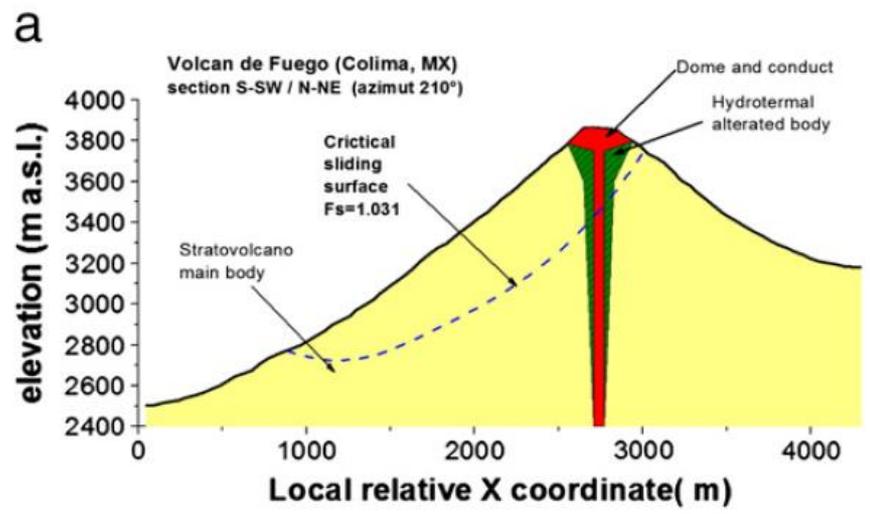


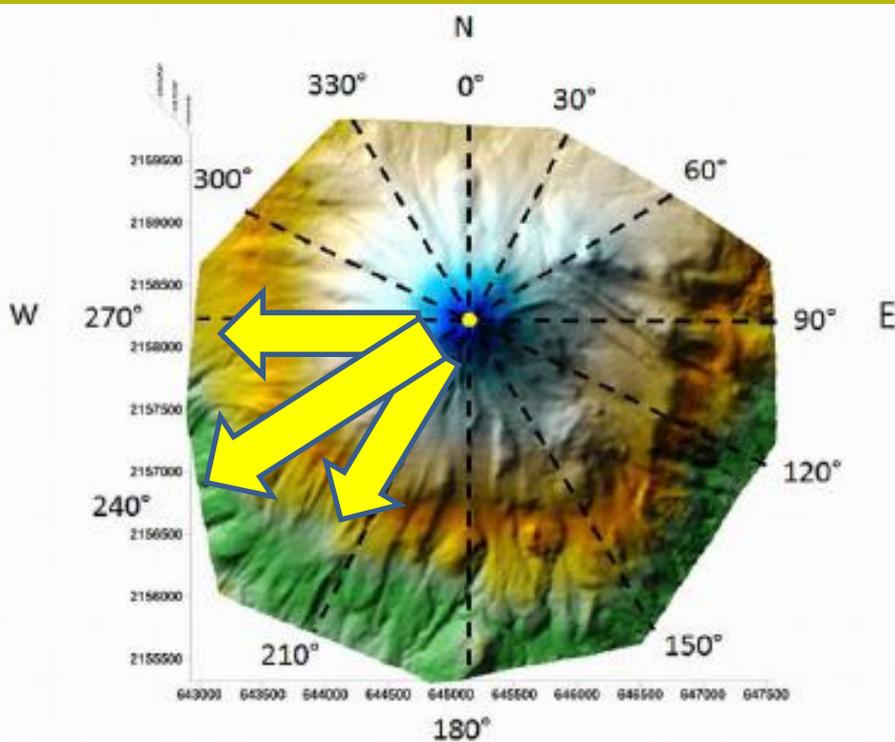


Volcan de Colima: ensayos de resultados finales con ALEM



L. Borselli et al. / Journal of Volcanology and Geothermal Research 208 (2011) 51–65





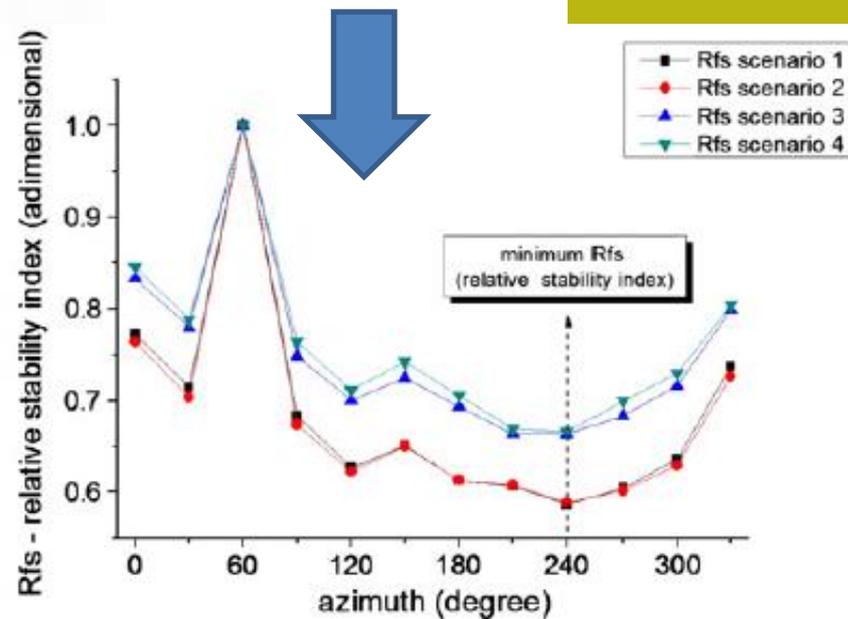
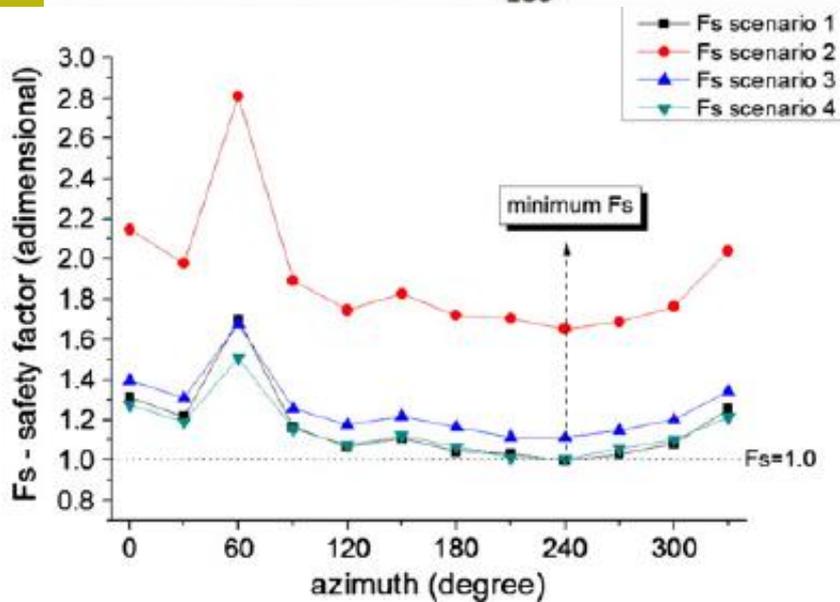
El sector con menor estabilidad relativa es el flanco W-SW (entre 270° y 210° de azimuth)

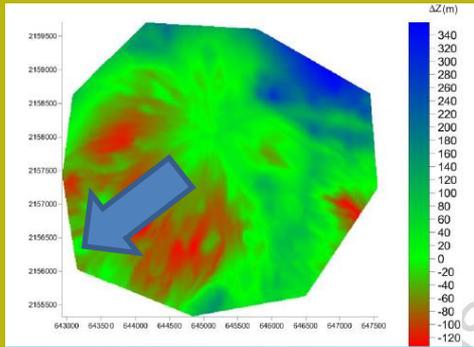
Relative stability index



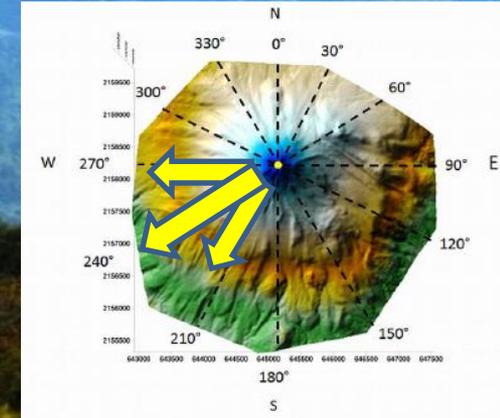
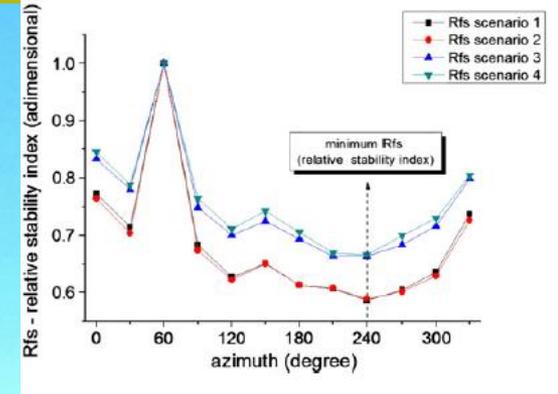
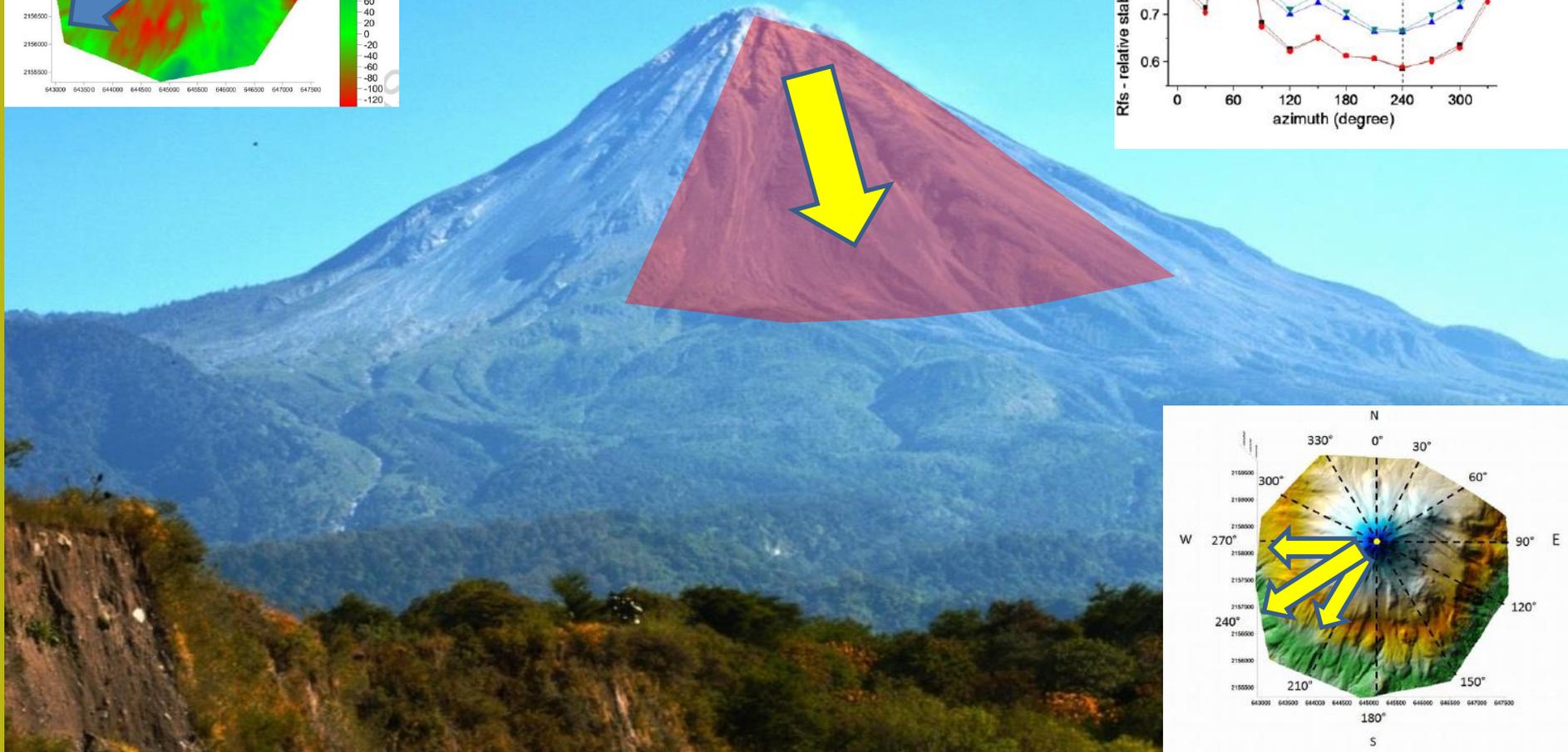
$$R_{f/s_i} = \frac{F_{s_i}}{F_{s_{max}}}$$

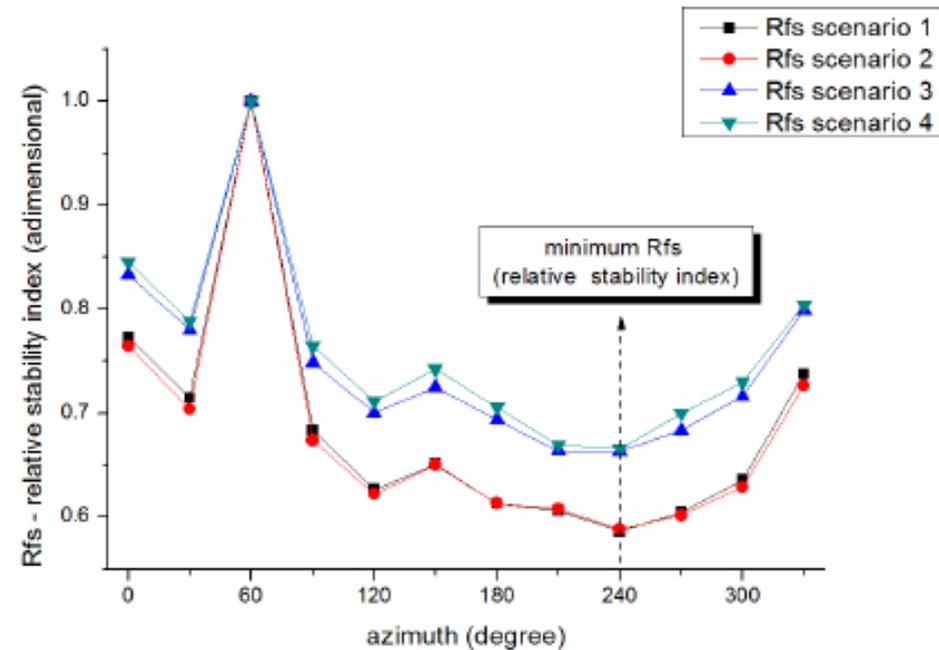
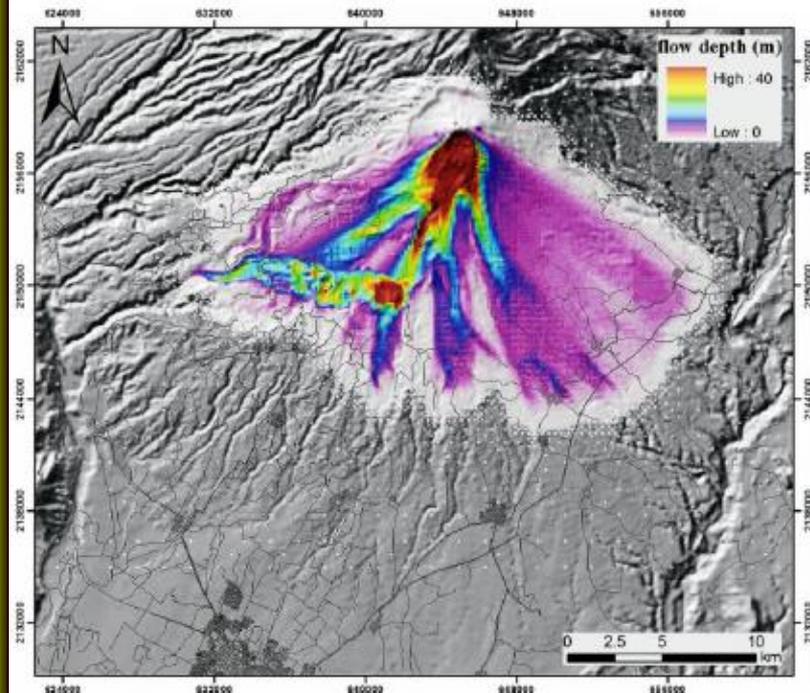
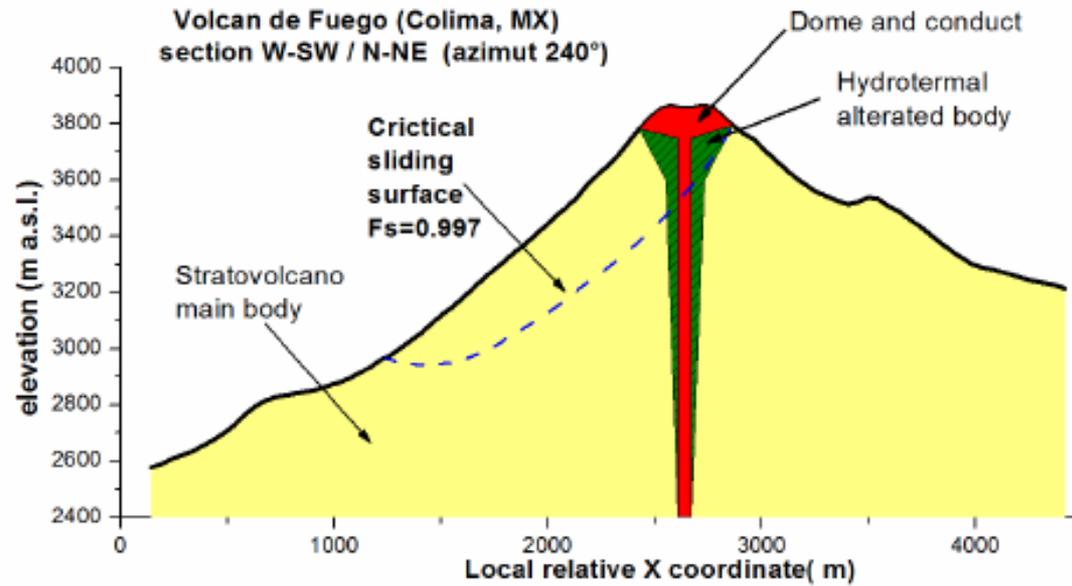
(Borselli et al. 2011)





The most potentially unstable
Flank: Azimuth 270°-210°





Volcanofit 2.0

WWW.VOLCANOFIT.ORG

$$Z = a e^{-\frac{\sqrt{(x-x_0)^2+(y-y_0)^2}}{b}} + c \text{ if } Z \leq Z_1$$

VOLCANOID SURFACE OF REVOLUTION

ALTERNATIVE VOLCANOID'S GENERATRIX

$$Z = a \cosh\left(\frac{r-c}{b}\right)$$

for $\forall r < c$ and $a, b, c > 0$.

$$Z = \frac{z_1 - a}{1 + e^{\frac{r-c}{b}}}$$

with $z_1 > a$ and $z_1, a, b, c > 0$.

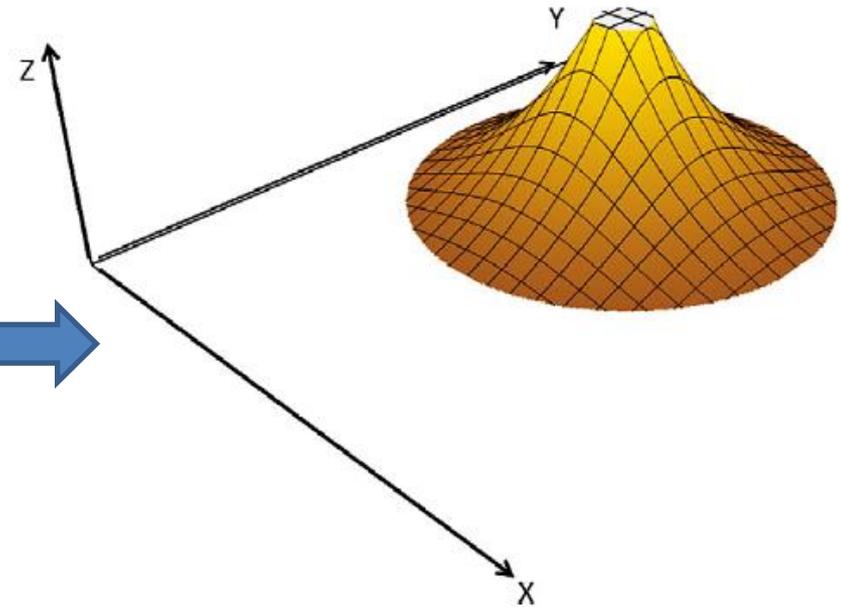


Fig. A.2. Example of volcanoid with constant negative curvature (Eq. (A.5)).

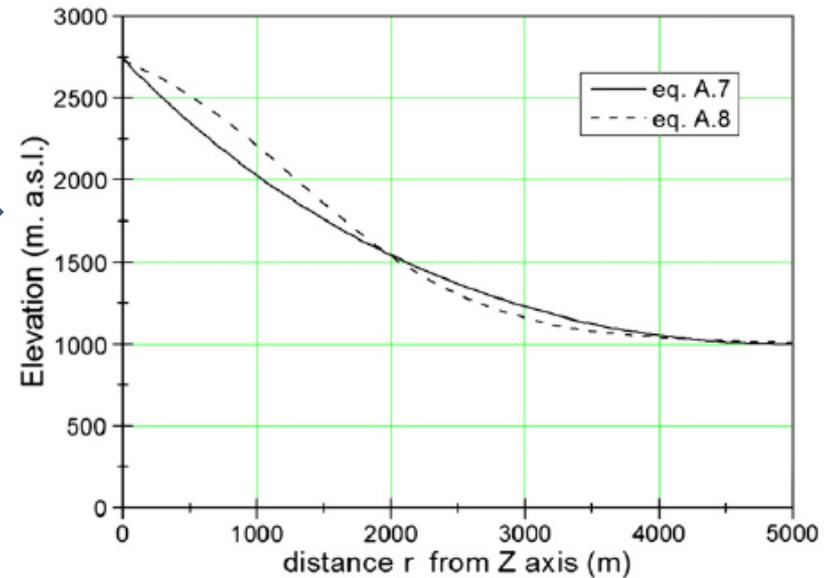
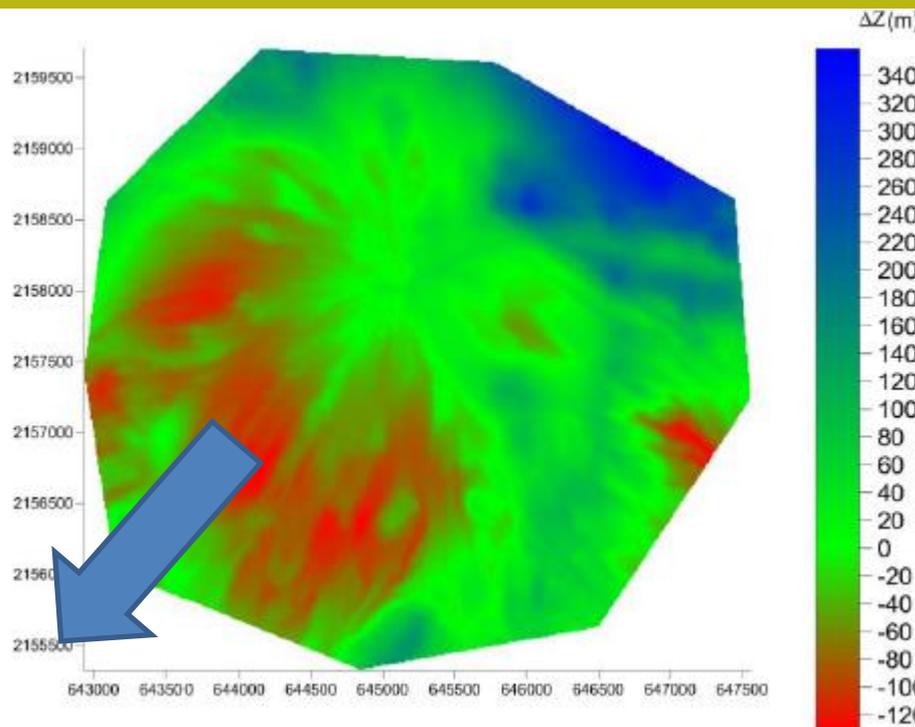
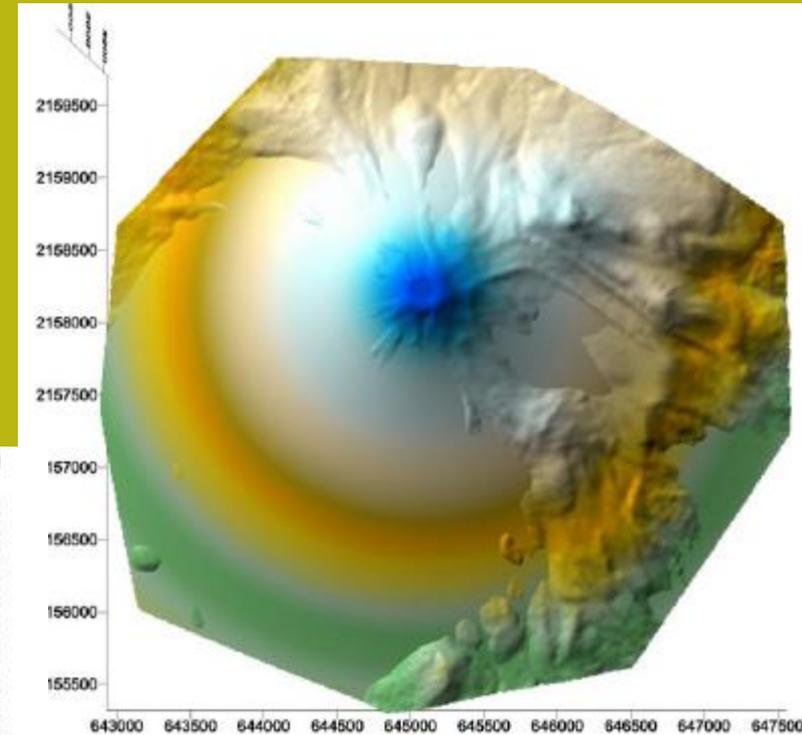
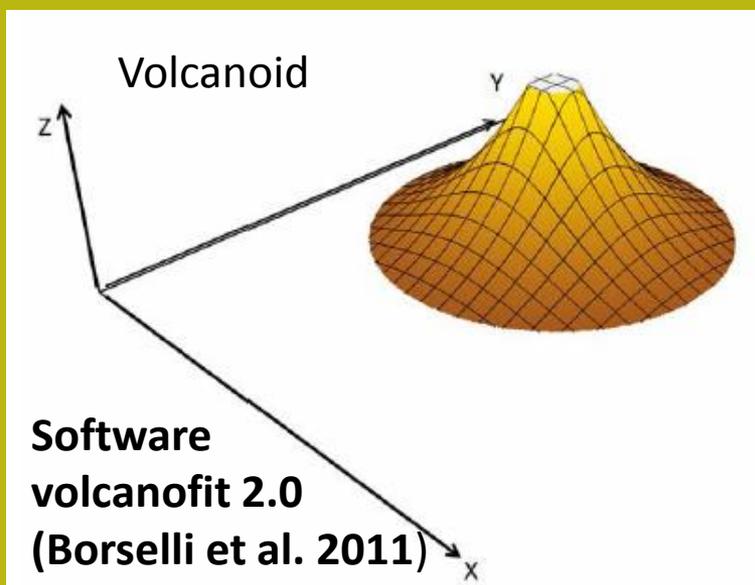


Fig. A.5. Alternative generatrix function of 3D volcanoid.

overlay de DEM y
Volcanoid (obtenido da VOLCANOFIT
2.0) www.volcanofit.org



Inestabilidad y Déficit de volumen
(y masa) en el flanco SW.
Borselli et al. 2011,
Borselli & Sarocchi 2012

SSAP2010 - Highlights

- Herramienta freeware de uso general que ya tiene un largo uso en Italia en profesionales, estudiantes, investigadores, empresas públicas y privadas. (aproximativamente son 400 downloads por mes)
- 21 años de desarrollo de código original, testing, aplicaciones, y interacción frecuente con los usuarios finales ..
- Muchos algoritmos originales..(*sniff random search.. Global optimization by DE... etc.; mapa Fs local 2D color*).
- Control de estabilidad numérica, gestión acuíferos, y presión de fluidos;
- Documentación técnica completa (*por el momento en italiano – manual PDF*) y muchos ejemplos de aplicación.
- Muchas Aplicaciones in Italia y algunas en México.
- Potencialidad en el desarrollo de nuevas funciones de calculo.
- Rápida curva de aprendizaje experimentada da los usuarios (geologo y ingenieros). Experimentada con muchos usuario en Italia..
- Aplicación a muchos casos con elevada de complejidad geo-mecanicas y hidráulica.
- **Gratis ... para todos.**
- *Se busca quien quiere financiar el proyecto la traducción oficial del Manual (140 paginas de texto) en español y en ingles (aproximativamente son 100,000 MXN)...*

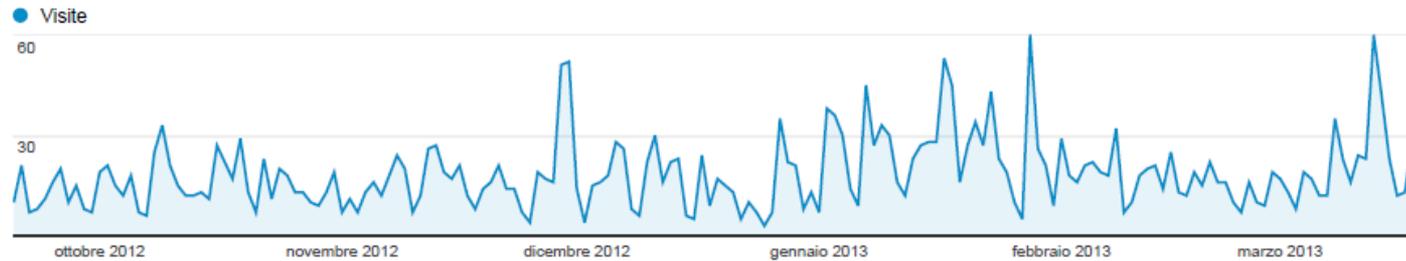
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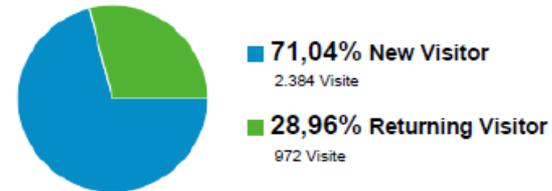
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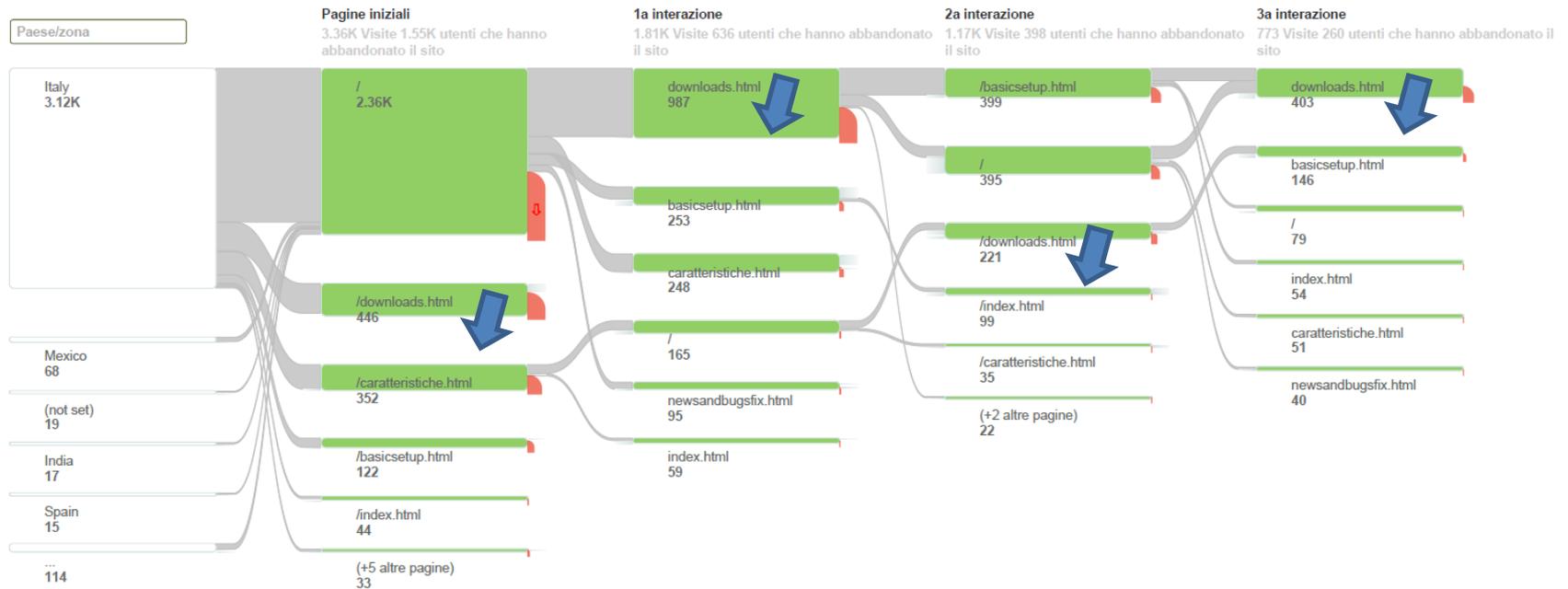
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972 Visite

Paese/zona	Visite	% Visite
1. Italy	3.123	 93,06%
2. Mexico	68	2,03%
3. (not set)	19	0,57%
4. India	17	0,51%
5. Spain	15	0,45%
6. Portugal	12	0,36%
7. France	7	0,21%
8. Brazil	6	0,18%
9. Dominica	6	0,18%
10. Peru	6	0,18%

Estadísticas de acceso por País

Flusso di visitatori



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Mas que 2623 descargas en los ultimo 6 meses
(considerando hasta la novena interacción.. Nel grafico arriba se muestra hasta la tercera)



SSAP 2010 (versione 4.2.0 - 2012)

SLOPE STABILITY ANALYSIS PROGRAM
release 4.2.0 (c) (1991-2012)
Aut. No. 5847
by Dr. Geol. Lorenzo Borselli, Ph.D.
lorenzo.borselli@uni.it
http://www.lorenzo-borselli.eu

AVVIO VERIFICA: VERIFICA GLOBALE | DIAGRAMMI FORZI | GENERA / VEDI MAPPA F.s. LOCALE
VERIFICA SINGOLA | VEDI GRAFICI SUPERFICI

MONITOR VERIFICA

MODELLO PRINCIPALE: LEGGI MODELLO | VEDI MODELLO | HELP

MODELLO DI CALCOLO: MODELLO DI CALCOLO: Parametri a Priori (1000)
COEFFICIENTE DI RIFRESCO: ORIZZONTALE (OK): 0.0000
VERTICALE (OK): 0.0000

PARAMETRI ATTIVI PER GENERAZIONE SUPERFICI

MOVITORE DI ENERGIA SUPERFICI	Convergenza Standard (mm/24h): 0.000
ZONA DI INIZIO - Progressiva - (m)	da 0.00 a 108.00
ZONA DI TERMINAZIONE - Progressiva - (m)	da 12.00 a 117.00
QUOTA LIMITI INFERIORE (m)	0.00
LUNGHEZZA MEDIA SEGMENTI - (m)	4.00
SMERZA SUPERFICI - (direzionale)	EFFETTO TENSIONI CRACKS: Attivo
RICERCA CON ATTIVAZIONE DINAMICO: (Elicito)	METODO Numerico (Fib. -)

RISULTATI IN TEMPO REALE:
F.s. ITERATIVO: 2.837
RANGE F.s. SUPERFICI CON MINORI F.s.: 1.440 - 1.521
% EFFICIENZA GENERAZIONE SUPERFICI: 29.6 (0.0000)
% EFFICIENZA GENERAZIONE SUPERFICI a % STABILITA' NUMERICA: 21.24 - 92.33

PERCENTUALE SUPERFICI COMPLETATE: 1.01 %

ESCI dal PROGRAMMA

MESSAGGI:
SUGGERIMENTO: effettuato una verifica di stabilità è possibile generare un rapporto (file di testo) con tutti i risultati e anche una serie di file DXF con i grafici e esportare un file con le coordinate della superficie critica.

PREMI ESC per Terminare - Premi INVIO/ENTER per stop temporaneo

STRUMENTI: GENERA REPORT VERIFICA | GENERA FILES DXF | ESPORTA SUPERFICI | CAMBIA PAR. GEOTECNICI

EDITA FILES: MAXFILES 3.2 | FILE SSAP2010.DIR

http://WWW.SSAP.EU

Gracias por su atención !!!

