GTS NX_線上課程

2D 開挖邊坡分析

台灣邁達斯

註:範例相關參數使用假設條件。

Subject

- 邊坡穩定分析
  - Limit Equilibrium Method(LEM)-極限平衡法
  - Stress Analysis Method (SAM)-應力分析法
  - Strength Reduction Method (SRM)-強度折減法
- 開挖分析
  - 水位線變化
  - 邊坡補強對開挖之影響(SAM/SRM)

平面應變元素

(Plane Strain Element)

A plane strain element is a triangular or rectangular element consisting of 3/4/6/8 nodes in a plane.

It is mainly used for the ground and structural analysis of dams or tunnels, which maintains a consistent section and has a long length in the direction normal to the section.

Because stress exists in the element thickness direction, it is technically not a 2D stress state.

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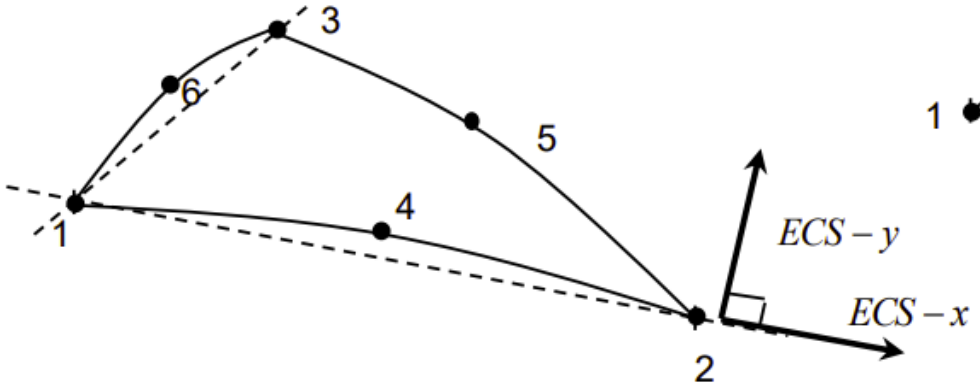
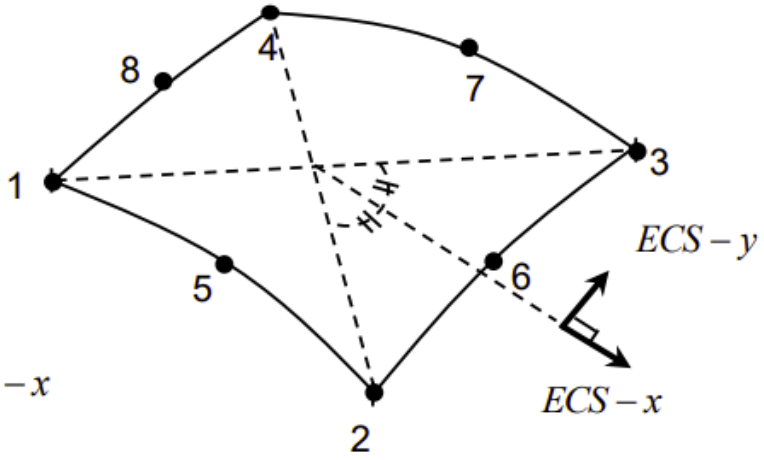




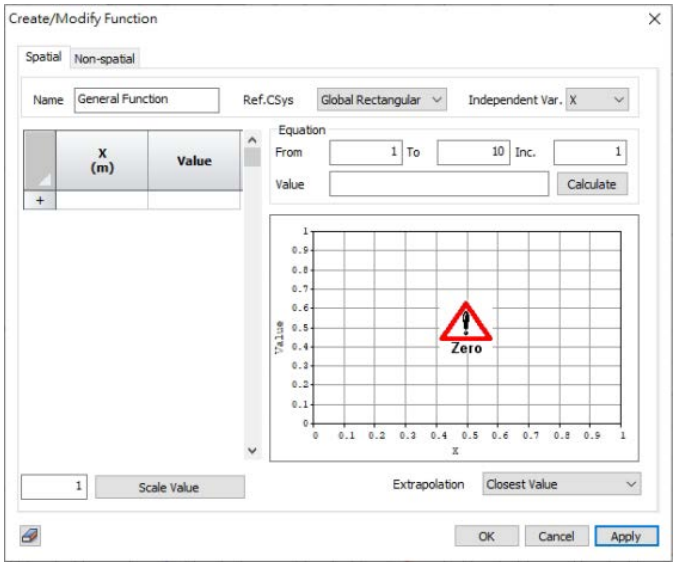
Reference

GTS NX & FEA NX Manual

Water Level

Water level

Water level function



方式1.Water Level For Global

Input the groundwater level that changes according to the construction stage with respect to the GCS.
Click to set the ground water level function.
If the water level and function are both specified, the input water level is multiplied onto the function and applied on the analysis.

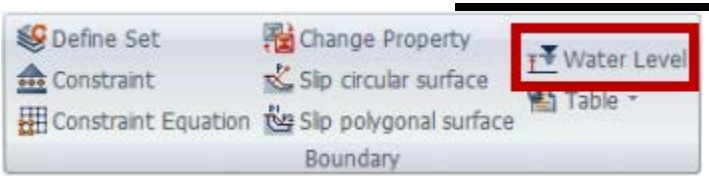
方式2.Water Level for Mesh Set

Define the groundwater level that changes according to the construction stage for each mesh set.
If the groundwater layer is surrounded by rocks or an impermeable clay layer (confined aquifer), the presence/absence of the groundwater level for each ground layer can be set for analysis.

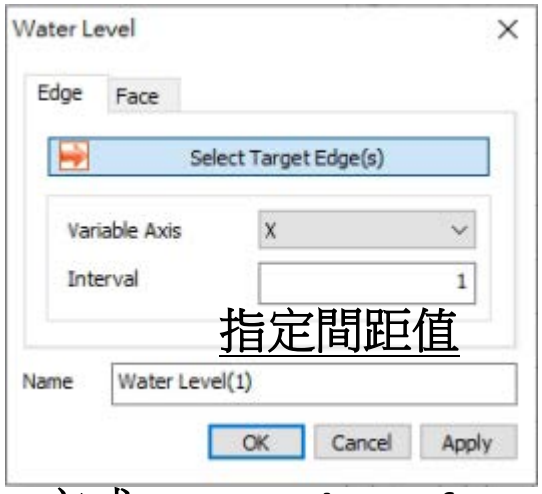
Reference

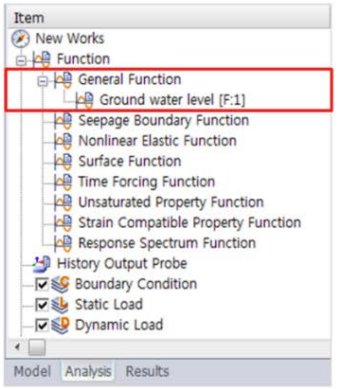
GTS NX & FEA NX Manual

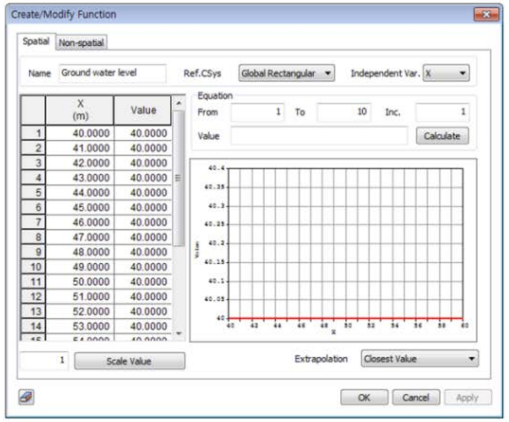
Water Level Function



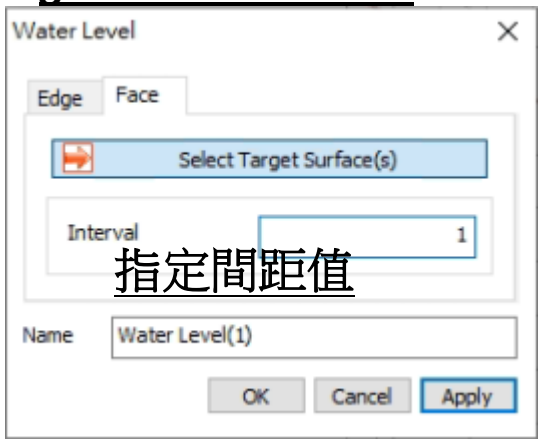
方式1.Edge:Create a changing groundwater level by selecting edges.

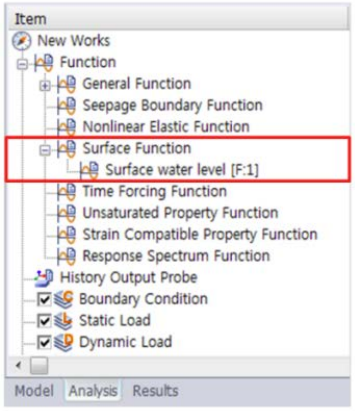


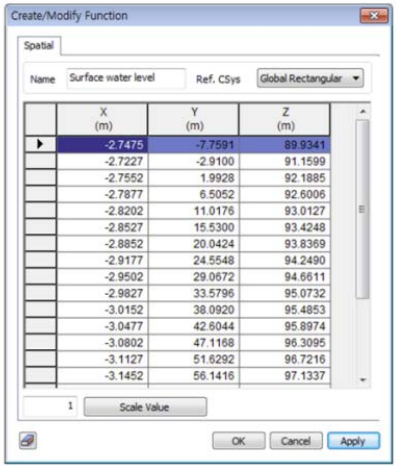




方式2.Face:Select a face and input the spacing value to create a changing groundwater level.





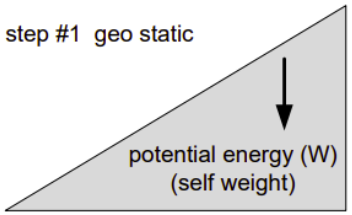


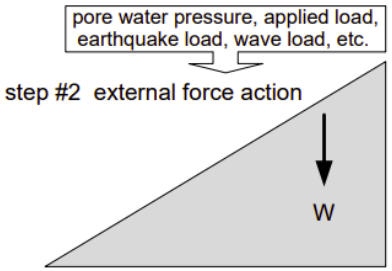
邊坡穩定分析

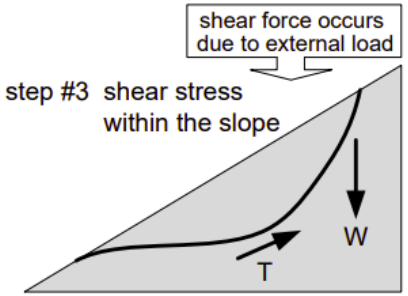
填築邊坡、開挖邊坡的穩定分析是大地工程分析中常見的分析內容，邊坡的自重、孔隙水壓、 附加載重、地震作用、波動水壓力載重對邊坡的穩定影響很大。

當自重和外力作用下，邊坡內部的剪應力大於邊坡岩土所具有的剪力強度時，邊坡將發生破壞。所以通過剪應力和剪力強度的分析來計算邊坡的穩定性的分析叫做邊坡穩定分析。

- **Soilworks /GTS NX**
  - Limit Equilibrium Method(LEM)-極限平衡法 2D
  - Stress Analysis Method (SAM)-應力分析法 2D
  - Strength Reduction Method (SRM)-強度折減法 2D/3D







Step #4 reacting on the shear strength of the slope(S)

$$F_s = \frac{S}{T}$$

Reference

GTS NX/FEA NX/Soilworks Manual

Limit Equilibrium Method(LEM)

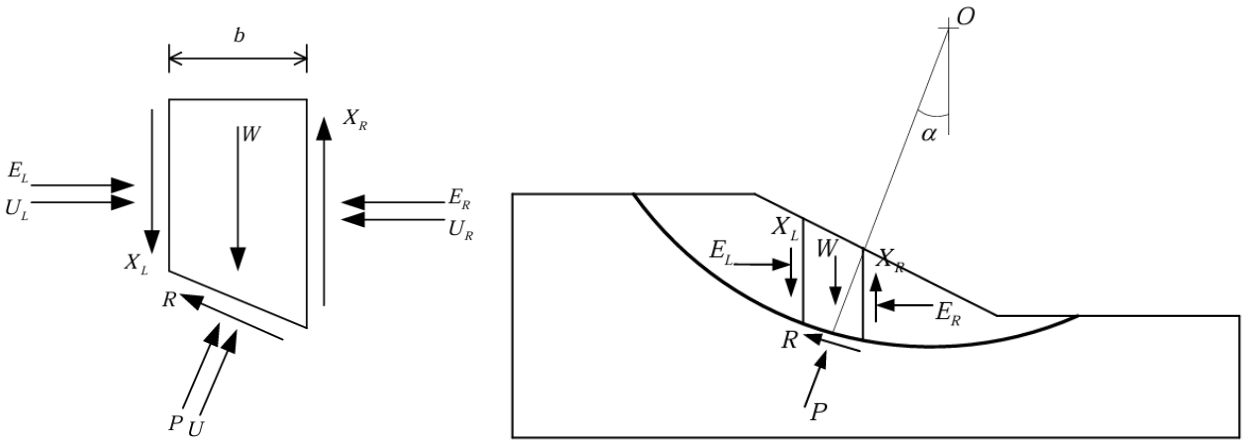
(極限平衡法)

極限平衡法(LEM)，計算滑動面位置相對於地表質量的力和力矩的平衡。基於此觀念，沿著假設的直線、圓弧或不規則的滑動面符合莫爾-庫侖破壞準則，計算在滑動面破壞時刻時的穩定性，透過兩個主要材料參數評估的破壞表面內聚力 (c) 和內摩擦角 (ϕ)。

The simplified Bishop method

由於其簡單性和相對精確度，在各種切片 方法中應用最為廣泛。
安全係數(F)需要透過迭代過程和試誤法來計算。

$$F=\frac{1}{\sum W\sin\alpha}\sum\left[\left\{c'l\cos\alpha+(W-ul\cos\alpha)\tan\phi'\right\}\left\{\frac{1}{m_\alpha}\right\}\right] \qquad \text{where, } m_\alpha=\cos\alpha\left(1+\frac{\tan\alpha\tan\phi}{F}\right)$$



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Stress Analysis Method (SAM)

(應力分析法)

邊坡穩定性分析大致分為簡化法和數值分析法。極限平衡法(LEM)是解決邊坡穩定問題應用最廣泛的簡化方法，但無法考慮邊坡形成過程中應力歷時的影響以及地下水所造成的地表應力變化。

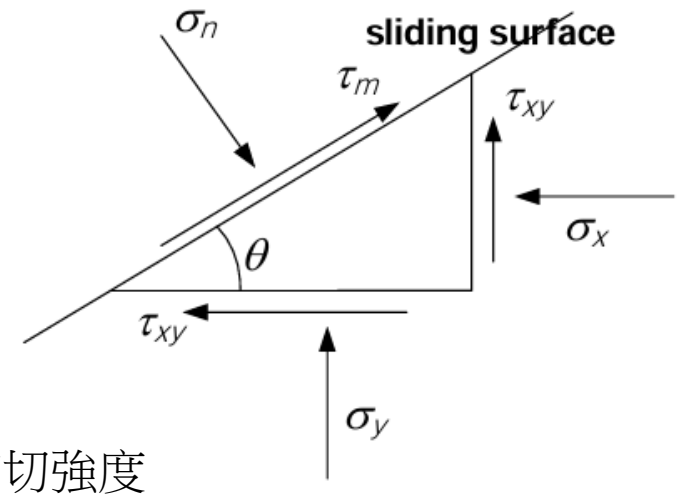
應力分析法(SAM)，使用有限元素法對斜坡進行應力分析，透過應力分析結果計算極限平衡法假設的多個潛在滑動面的安全係數，確定最小安全係數和相應的臨界截面。有限元素方法中所使用的安全係數定義為：

$$F_s = \frac{\int_S \tau_f d\Gamma}{\int_S \tau_m d\Gamma}$$

$$\tau_f = c + \sigma_n \tan\phi$$

$$\tau_m = \frac{1}{2}\left(\sigma_y - \sigma_x\right)\sin 2\theta + \tau_{xy}\cos 2\theta$$

$$\sigma_n = \sigma_x \sin^2\theta + \sigma_y \cos^2\theta - \tau_{xy}\sin 2\theta$$



τ_f :根據莫爾庫侖失效準則計算的剪切強度
τ_m :誘導剪切強度
σ_n :垂直於滑動表面的應力

平面應變元素

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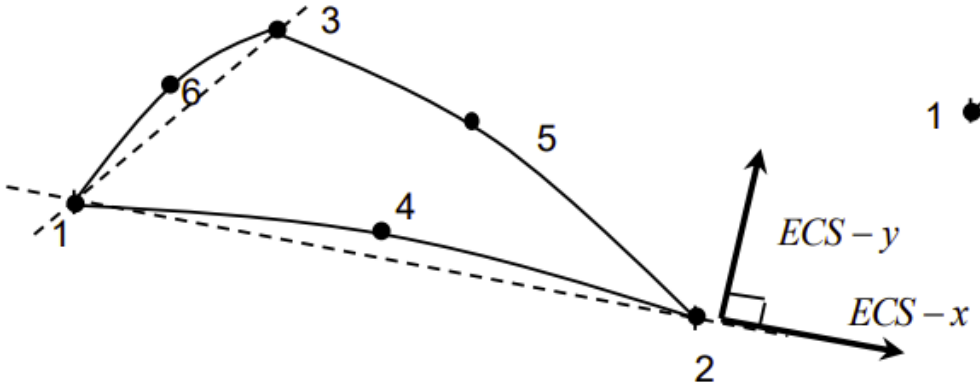

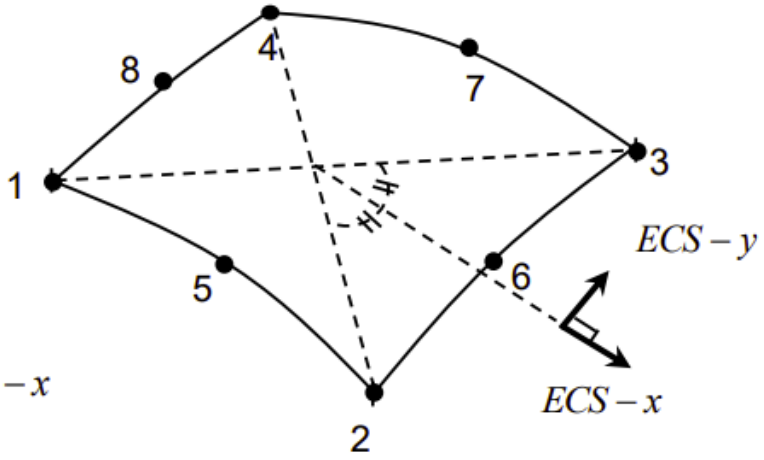

Reference

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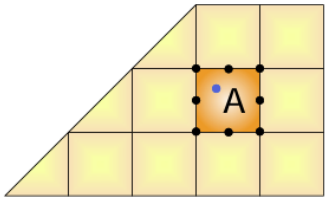
Strength Reduction Method (SRM)

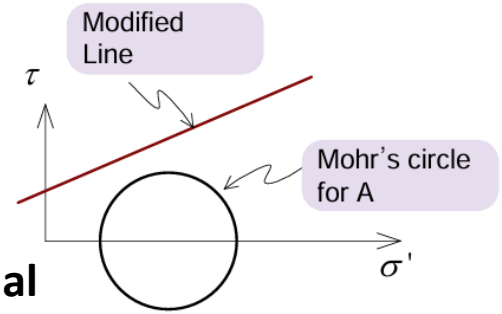
(強度折減法)

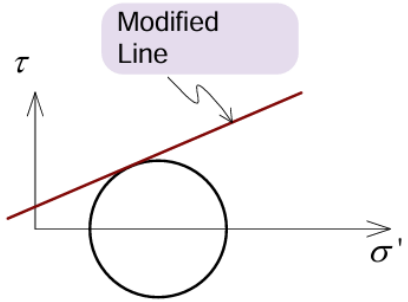
有限元素法分析邊坡穩定性的方法有兩類：
(1)直接法:強度折減法
(2)間接法:應力分析法(結合極限平衡法進行安全係數計算)

強度折減法(SRM)

將邊坡地基材料的抗剪強度 (c , ϕ) 逐漸減小，直到計算中的發散點，此時假定發生了斜坡破壞，該點的最大強度折減率被認為是最小安全係數。
強度折減法需要迭代非線性分析，消耗大量分析時間，
(1) 當土體的抗剪強度小於土體自重所引起的剪應力時，就會發生破壞，所以不需假設失效面。
(2) 不需使用切片的概念直接進行計算，同時滿足平衡狀態直致失效。
(3) 計算得到現地邊應力和變形。







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