

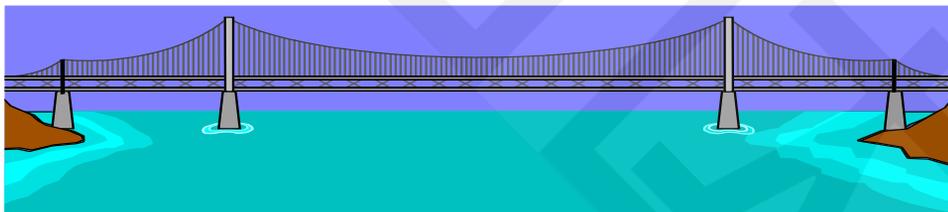
SAP2000 移动荷载分析

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北京筑信达工程咨询有限公司

2024年5月22日

移动荷载



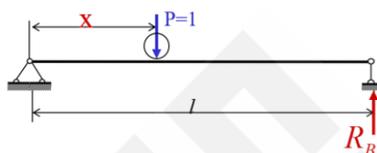
移动荷载（如：吊车荷载、汽车荷载、列车荷载）

- 荷载的大小和方向不变
- 荷载的**作用点**随时间改变
- 结构产生的加速度（惯性力）可忽略→静力分析
- **结构响应（内力、反力、位移等）**随荷载作用点改变

影响线！

影响线

❖ 静力法 (SAP2000)



$$R_B = \frac{x}{l} P = \frac{x}{l} (0 \leq x \leq l)$$

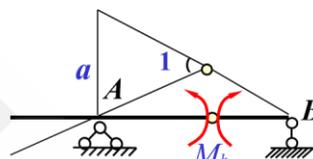
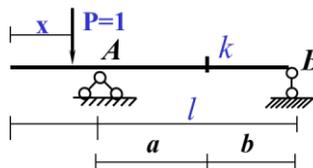
解析表达式 (SAP2000)



支座反力 R_B 的影响线

❖ 机动法 (手算)

- 虚位移原理：静力问题 → 几何问题
- 方法巧妙但不适合编制计算机程序



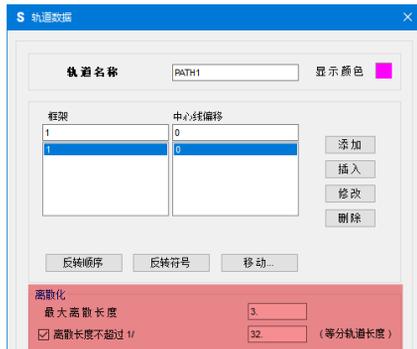
k截面的弯矩影响线

筑信达

轨道和车辆荷载

❖ 轨道数据

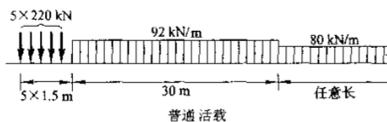
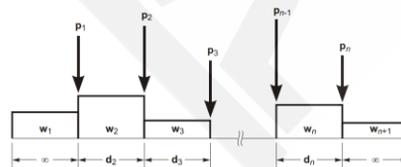
- 框架对象组：荷载作用范围
- 离散化：荷载作用点 (加载点)



❖ 车辆荷载

- 集中荷载 (轴重或轮压)
- 均布线荷载 (车辆平均重量)

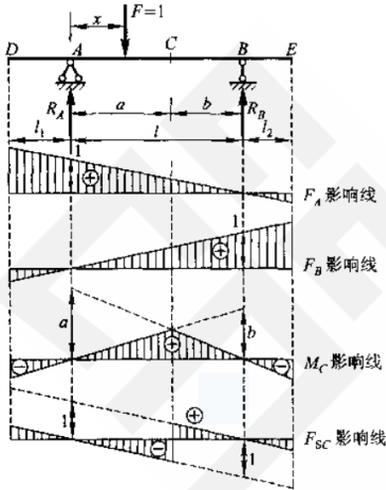
$n-1$ 个轴距, n 个集中荷载, $n+1$ 个均布线荷载



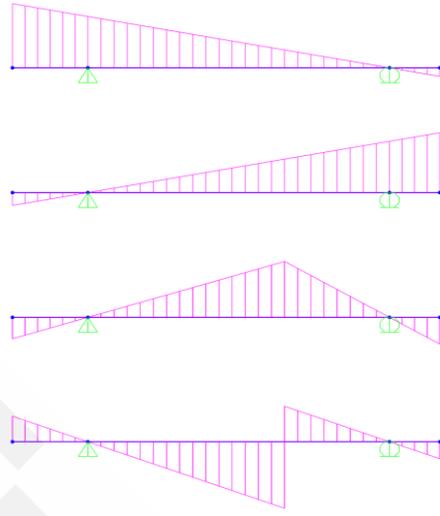
筑信达

静定梁的影响线

❖ 伸臂简支梁



教科书

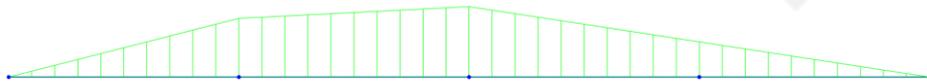
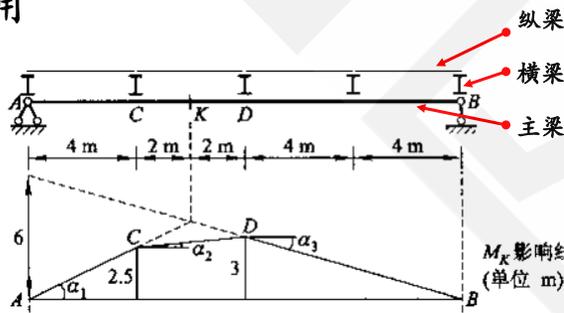


SAP2000

筑信达

静定梁的影响线

❖ 间接荷载作用

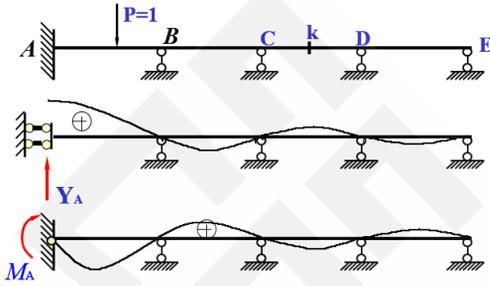


SAP2000 (辅助梁)

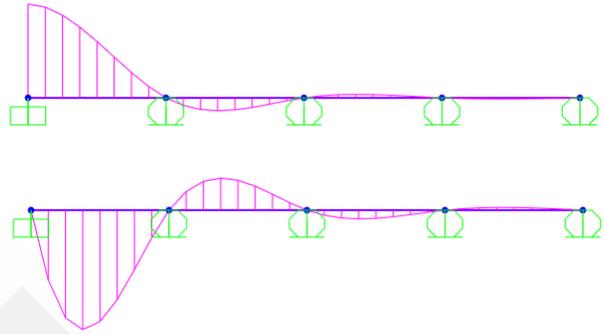
筑信达

超静定梁的影响线

❖ 多跨连续梁



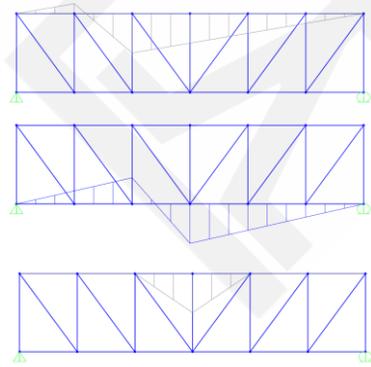
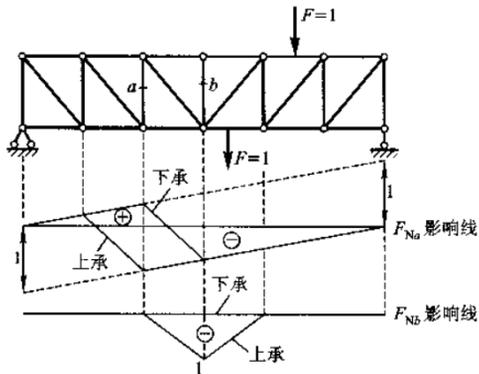
曲线形式的影响线



SAP2000 (加载点)

静定桁架的影响线

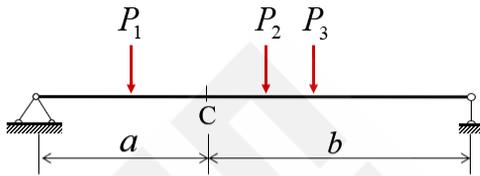
❖ 平行弦桁架



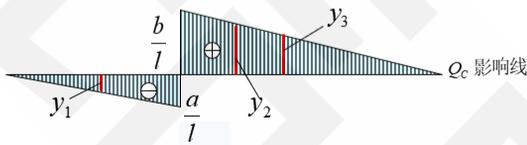
SAP2000

影响线的应用 1

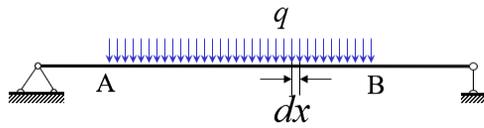
❖ 固定荷载作用下的结构响应



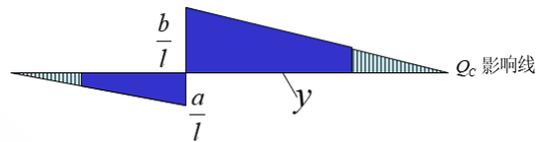
$$Q_C = P_1 \cdot y_1 + P_2 \cdot y_2 + P_3 \cdot y_3$$



集中荷载



$$Q_C = \int_A^B q \cdot dx \cdot y = q \int_A^B y dx = q \cdot \omega_{AB}$$

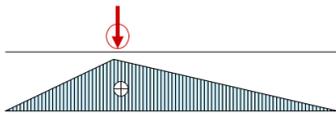


分布荷载

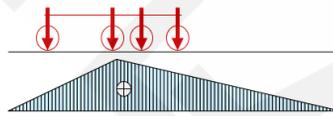
筑信达

影响线的应用 2

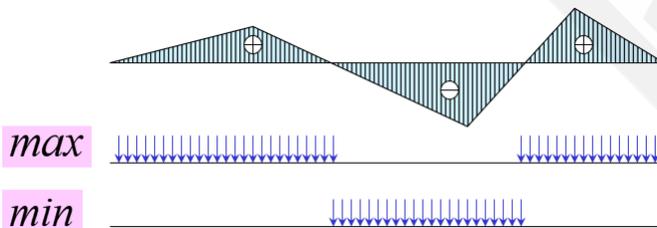
❖ 荷载的最不利布置



单个集中荷载



一组集中荷载

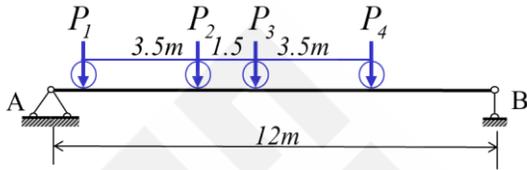


分布荷载

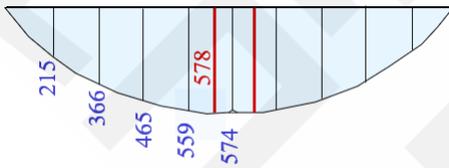
筑信达

影响线的应用 3

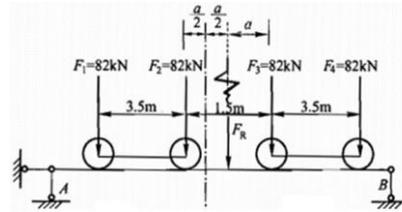
绝对最大弯矩和内力包络图



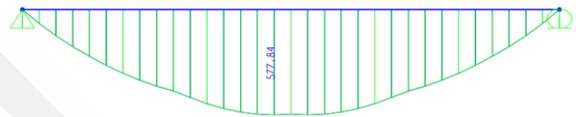
$$P_1 = P_2 = P_3 = P_4 = 82 \text{ kN}$$



弯矩包络图 (kN·m)



最不利荷载布置

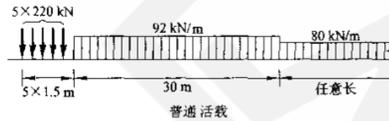
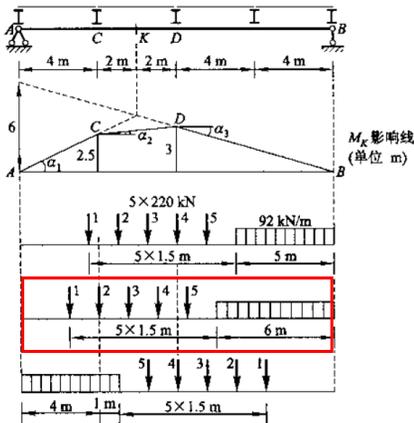


弯矩包络图
(SAP2000)

筑信达

影响线的应用 3

绝对最大弯矩和内力包络图



$$M_K = \sum F_i y_i$$

$$= 220 \text{ kN} \times 1.5625 \text{ m} + 660 \text{ kN} \times 2.6875 \text{ m} + 220 \text{ kN} \times 2.8125 \text{ m} + 92 \text{ kN/m} \times 6 \text{ m} \times 1.125 \text{ m} = 3357 \text{ kN}\cdot\text{m}$$



SAP2000

筑信达

谢 谢

“The idea that an expert-system computer program, with artificial intelligence, will replace a **creative human is an insult to all structural engineers.”**



加州大学伯克利分校终身名誉教授 Edward L. Wilson (著名的结构分析设计软件 SAP 的创始人) 在《Three Dimensional Static and Dynamic Analysis Of Structures》(<http://www.edwilson.org/Book/book.htm#Personal>) 一书中提到:

"Don't use a structural analysis program unless you fully understand the theory and approximations used within the program"

"Don't create a computer model until the loading, material properties and boundary conditions are clearly defined"