



有限元分析的典型 Project

【应用建模 Project3】 振动模态分析：斜拉桥的模态分析

计算分析模型如图 3.1 所示，桥梁结构的有关参数见表 3.1。在 ANSYS 中所使用的文件名：**bridge**。

【建模要点】

1. 采用循环命令建立相应的关键点和桥面，并通过复制，镜像对称方式构建模型；
2. 镜像对称复制后产生位置相同但编号不同的节点和线，通过 nummrg 命令将该重复节点和线粘合一起

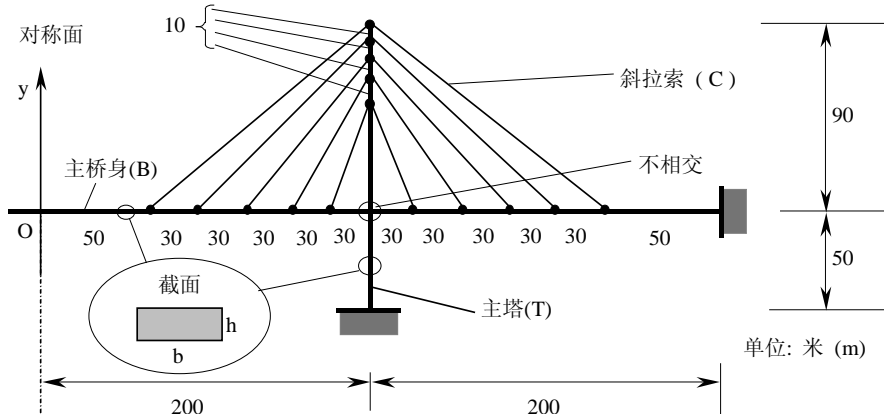


图 3.1 斜拉桥的计算分析模型

表 3.1 桥梁结构的参数

主桥身(B)	$I_B = \frac{bh^3}{12} = 12.26m^4$	$A_B = 15m^2$	$h = 3.1m$	$b = 4.84m$
主塔(T)	$I_C = \frac{bh^3}{12} = 129.98m^4$	$A_T = 28m^2$	$h = 7.464m$	$b = 3.751m$
斜拉索(C)	$I_C = \frac{\pi \cdot d^4}{64}$	$A_C = 0.02545m^2$	$r = 0.09m$	
桥面	桥面宽 14m	桥面厚度 $t = 0.5m$		
所有材料	$E = 2.1 \times 10^{11} Pa$	$\rho = 7500 kg/m^3$	$\mu = 0.3$	

建模要求

- (1) 右端完整建模，然后用映射方法(Reflect)生成对称结构；
- (2) 单元建模：3D 模型，主桥身与主塔：Beam(2D)；斜拉索：Link 单元(tension only: 不承受压载荷)。

计算所得到的模态分析结果见图 11.2。

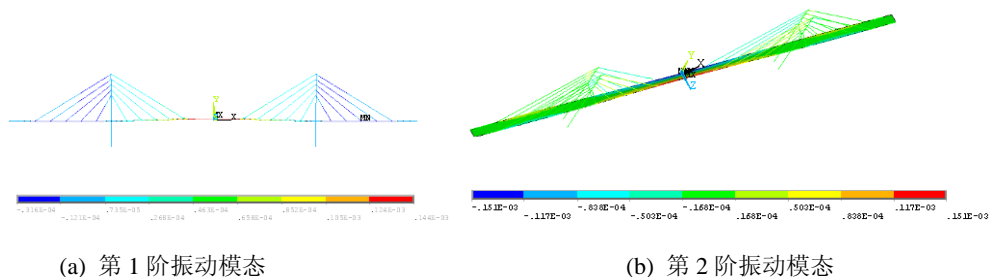


图 11.2 斜拉桥的振动模式

11.3.2 完全的直接命令输入方式操作

以下为命令流语句。

```

!%%%%%%%% [应用建模 Project3] %%%% begin %%%%%%%%%
/prep7                                !preprocessor
et,1,beam3                             !define the elements
et,2,link10
et,3,shell181
mp,ex,1,2.1e11                          !define materials parameters
mp,prxy,1,0.3
mp,dens,1,7500
r,1,15,12.26,3.1
r,2,28,129.98,7.464
r,3,0.02545
r,4,0.5
k,1,,,                                  !define key points of bridge body
k,2,50,,, $ k,3,80,,, $ k,4,110,,, $ k,5,140,,, $ k,6,170,,, $ k,7,230,,, $ k,8,260,,,
k,9,290,,, $ k,10,320,, $ k,11,350,, $ k,12,400,,
k,13,200,90,,                            !define key points of supporting tower
k,14,200,80,, $k,15,200,70,, $k,16,200,60,, $k,17,200,50,, $ k,18,200,-50,,
*do,i,1,11,1                             !link these points to a bridge body
l,i,i+1
*enddo
*do,i,13,17,1                             !link these points to a tower
l,i,i+1
*enddo
*do,i,0,4,1                               !link these points to some tensing cables
l,i+2,13+i
l,11-i,13+i
*enddo
lmesh,1,11,1                             !meshing the bridge with default mesh attributes
real,2                                    !set mesh with real constant as 2
lmesh,12,16,1                             !meshing tower
real,3                                    !set mesh with real constant as 3
type,2                                    !set mesh with element type 2 (link10)

```



```
lmesh,17,26,1          !meshing cables
lgen,2,all,,0,0,14     !copy the line of the tower,cables
*do,i,1,11,1
a,i,i+1,i+19,i+18     ! define the bridge deck
*enddo
real,4
type,3                 ! define the element type as shell element for bridge deck
esize,14               !set the size of shell element
amesh,all              !meshing the bridge deck
arsym,x,all            !mirror bridge deck area with Y axis
lsym,x,all              !mirror the other part of the bridge with Y axis
nummrg,all             !merge the overlap part
/solution
dk,18,all,0            !constrain the relate keypoints
dk,36,all,0
dk,78,all,0
dk,96,all,0
dl,64,,all,            !constrain the relate lines
dl,97,,all
antype,2               !set analysis type as model analysis
modopt,lanb,10,0.01,100,, !select analysis methods as Block Lanczos
                          !Number of modes to extract:10
                          !Beginning frequency of interest:0.01
                          !Ending frequency of interest: 100
solve
/post1                 !postprocessor
set,first              !set first model shape
pldisp,1               !plot deformed shape with undeformed shape
!%%%%%%%%%% [应用建模 Project3] %%%%%%%%% end %%%%%%%%%
```