# TURNING TORSO @ MALMO, SWEDEN

# BY SANTIAGO CALATRAVA

arch 631 case study
turning torso

# santiago calatrava

artist

structural engineer

architect

# structure

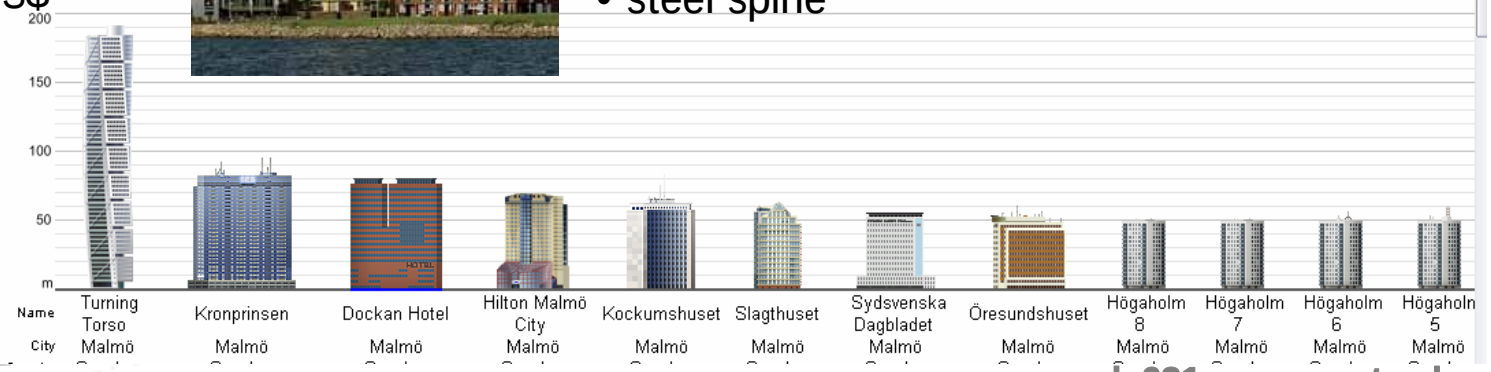
- no of floors – 57
- basement – 2
- height – 190.4 mts
- 9 cubes of 5 floors each
- each floor: 1.6 deg
- each cube: 10 deg

# facts

- building : mixed use
- 1st to 2nd cube : commercial space
- 3rd to 9th cube: residential space
- cost : 235million US$

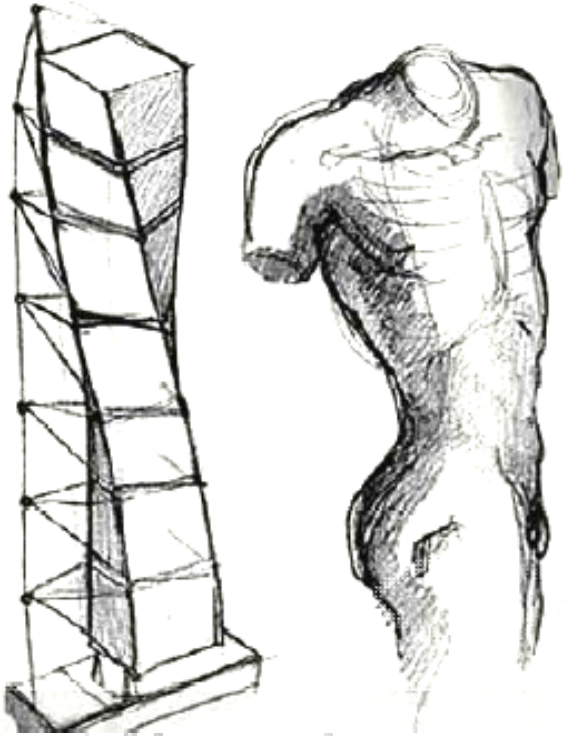
# materials

- concrete core-shear walls
- concrete floor slabs
- steel spine




arch 631 case study
turning torso

# architectural concept



- designed to look like a turning human body
- nine vertically stacked cubes
- twisted 90 degrees from bottom to top
- steel spine twists along with the structure similar to spine and ribs of the human body

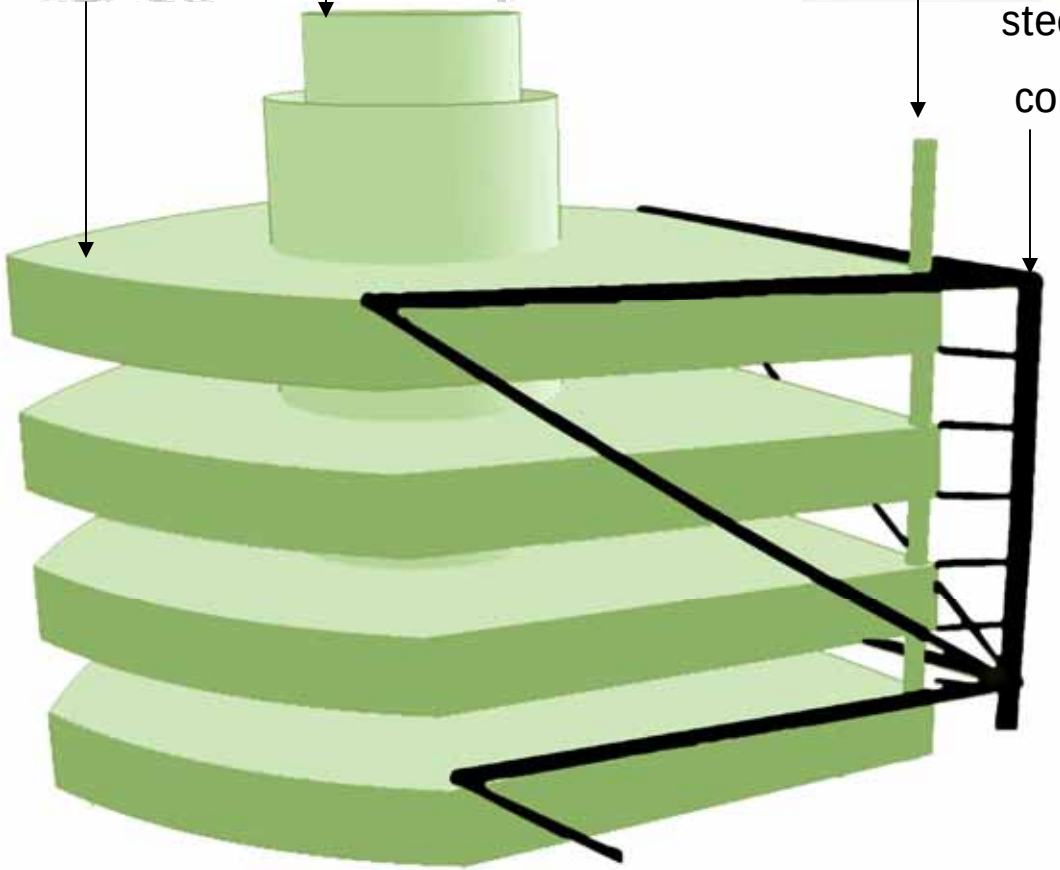
# structural concept

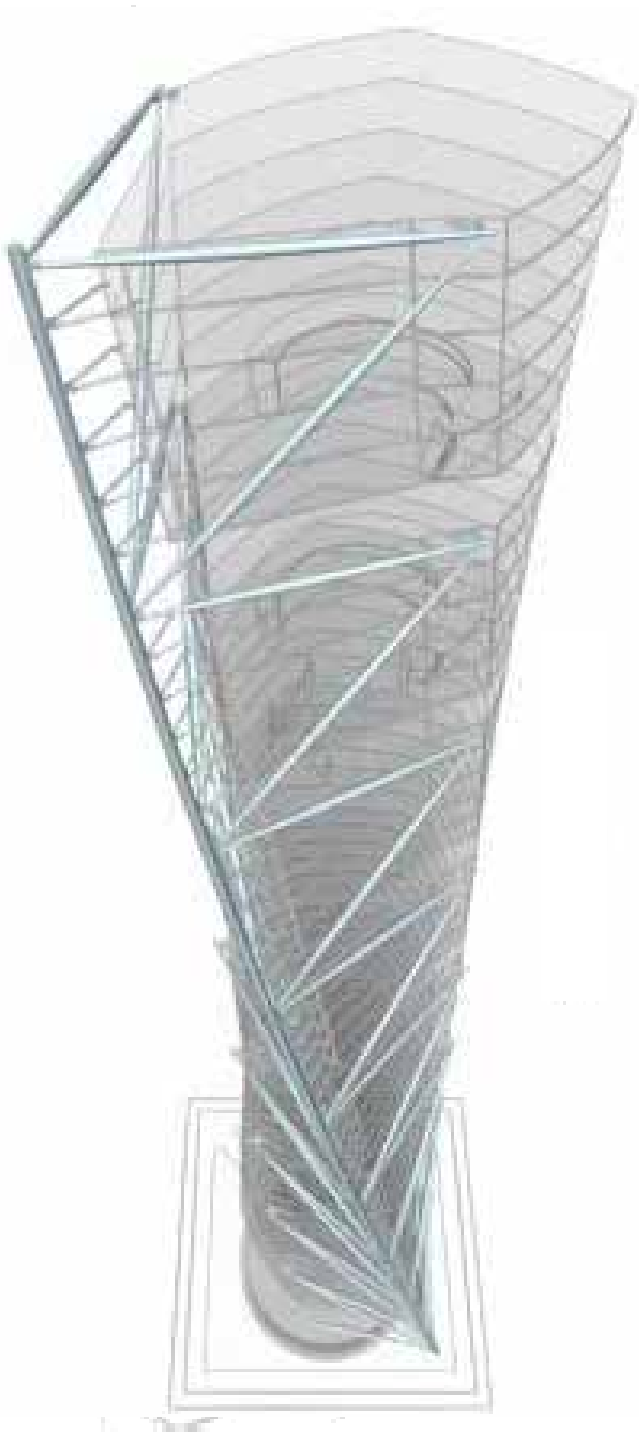
concrete floor slab
1ft thk cantilevered
from the core

concrete tube core r =10.6 mts

concrete perimeter column

steel spine pin
connected





## steel spine

- as exoskeleton for the structure
- reduces wind displacement
- acts as a reinforcing truss
- consists of 20 horizontal and 18 diagonal members known as cigars

## lateral load transfer

steel spine

↓

perimeter walls

↓

cantilever floor slabs

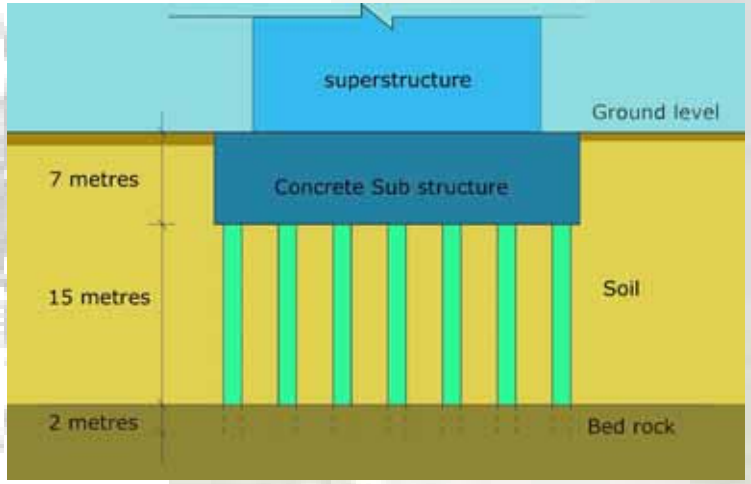
↓

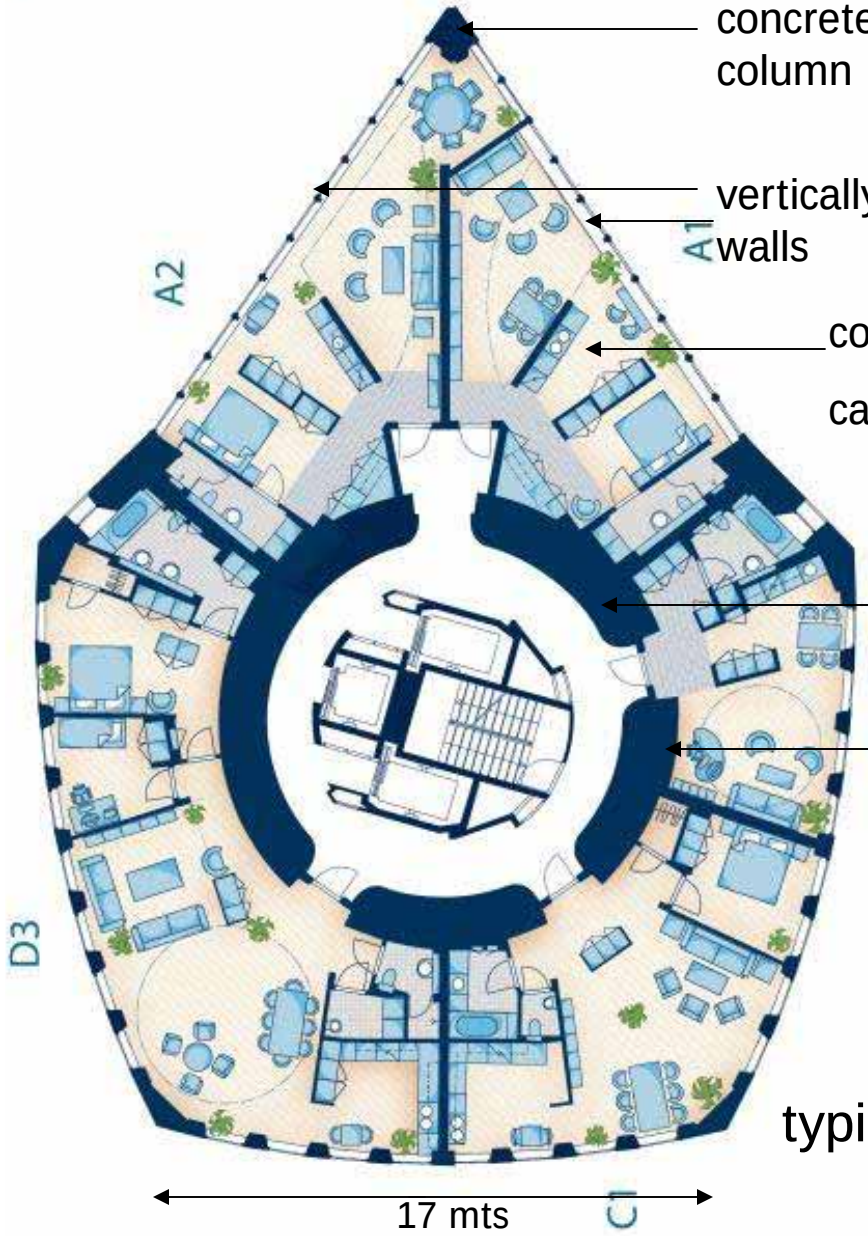
central core

↓

foundation

## foundation






concrete perimeter column

vertically continuous perimeter walls

concrete floor slab

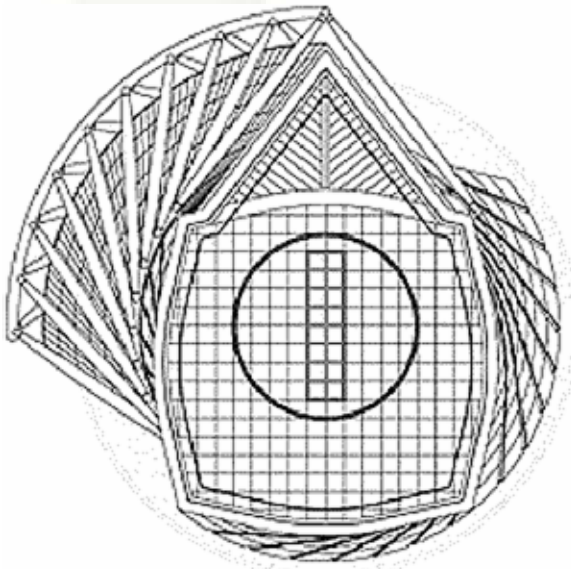
cantilevered from core

circular hallway

concrete core

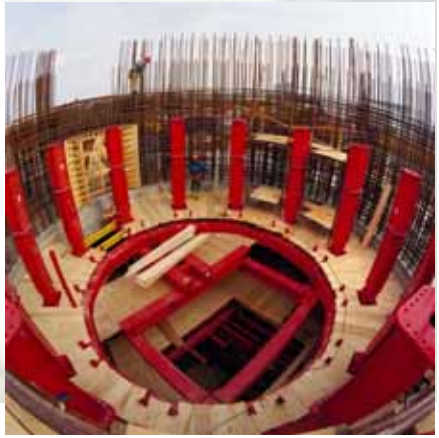
glass and aluminium facade

typical floor plan



# construction process

- self climbing slip forms
- steel spine erected using air-driven winches
- steel treated with special anti-corrosive paint

# analysis

wind load calculations

velocity pressure =

$q_z = 0.613. K_z .K_{zt} .K_d .V^2. I$ $(N/m^2)$

design wind load =

$F = q_z.G.C_f.A_f$ (N)

wind velocity at each floor =

$V_r.(h/h_r).K$

wind velocity (reference) =

$V_r$ = 44m/sec

$h_r$ = 10 mts

h = ht of floor above ground

K = 1/5

$K_z$ = exposure category

$K_{zt}$ = topographic factor

$K_d$ = wind directionality factor

V = wind speed

I = importance factor

G = gust effect factor

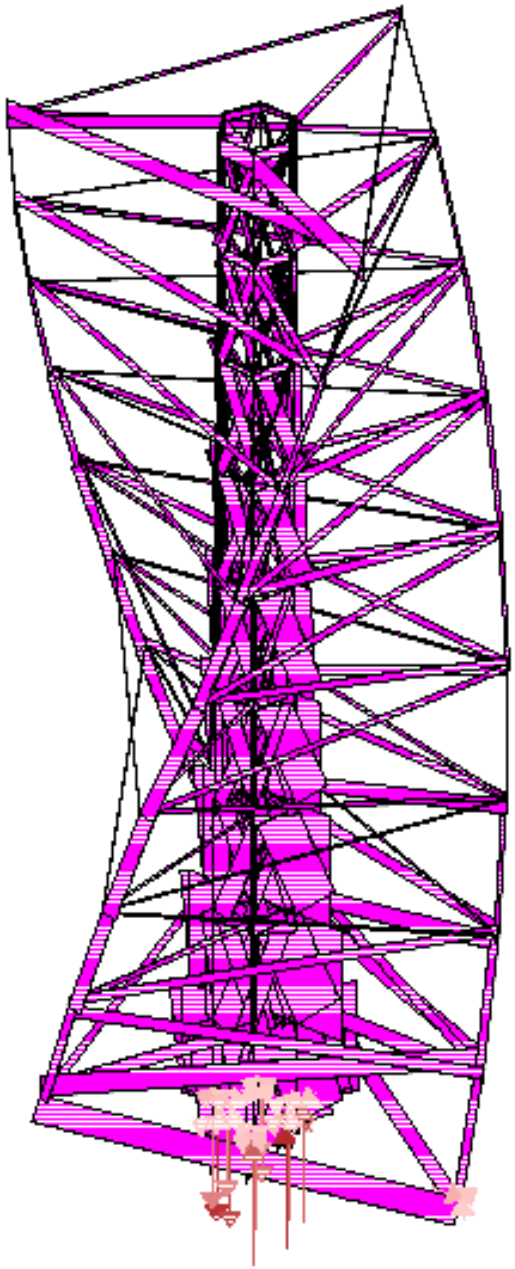
$C_f$ = force coefficient

$A_f$ = projected area

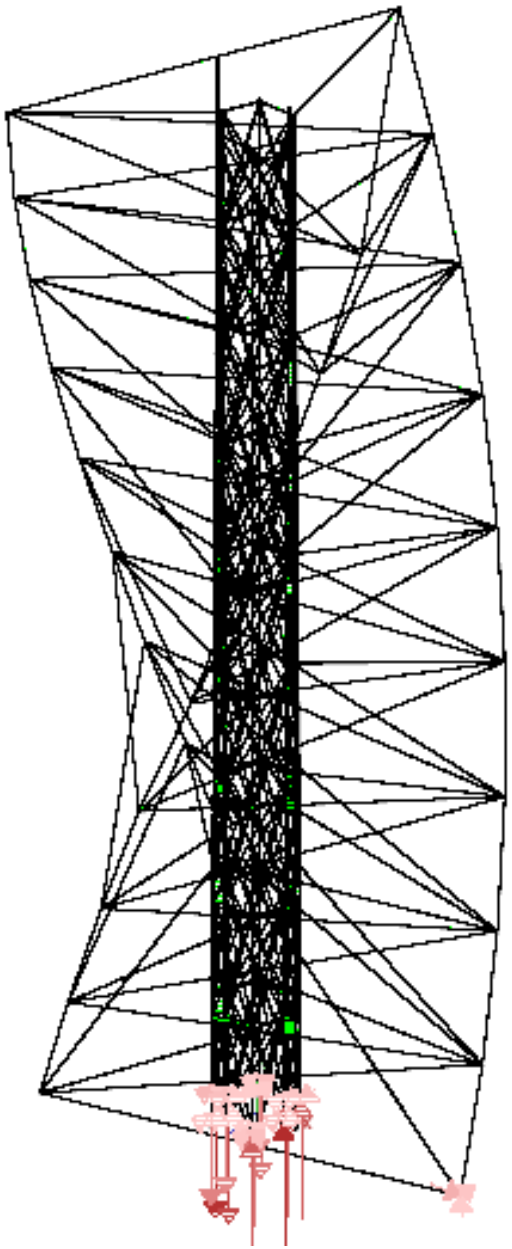
note:

- all values from ASCE-07
- all factors are generic factors not dependent on geographic location

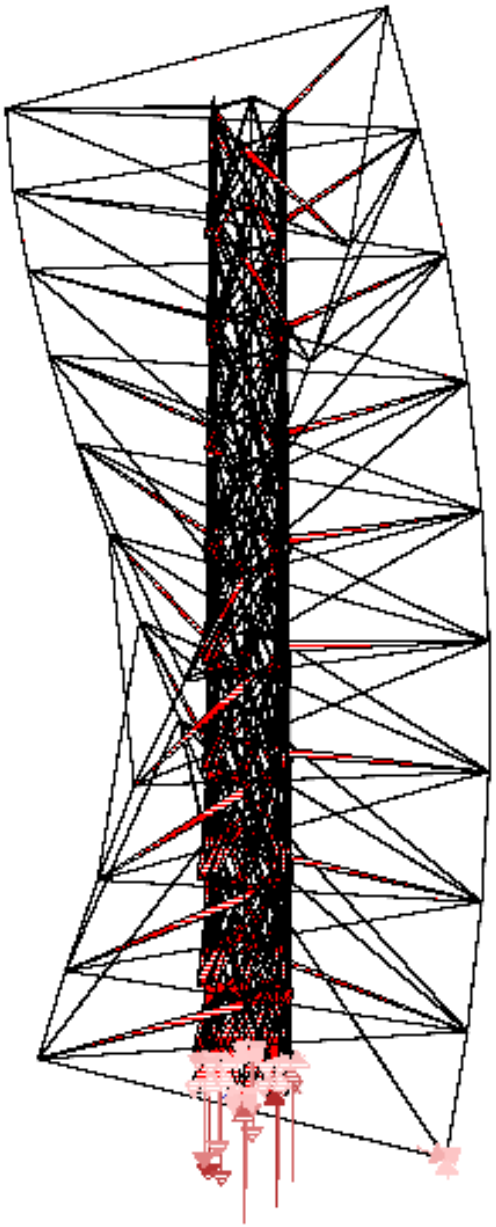
axial force diagram



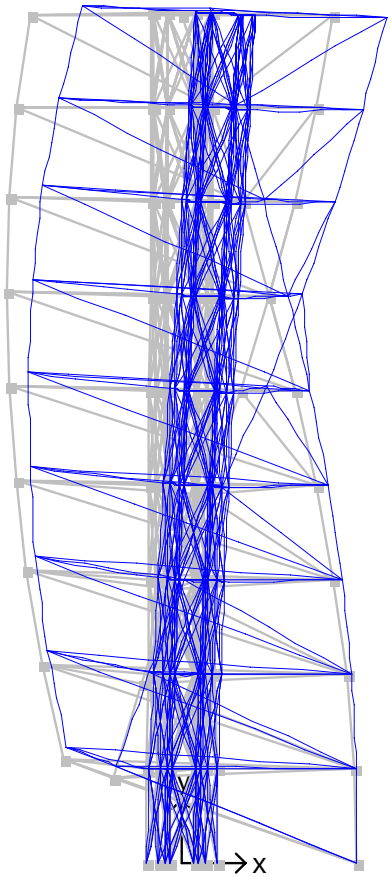
shear force diagram



moment diagram



deflection diagram + anim



## conclusion

• example of a structure where steel exoskeleton is used as an efficient lateral bracing mechanism

• central core in concrete is the main element responsible for transferring vertical loads towards the foundation

## resources


• http://skyscraperpage.com/diagrams/?b8368

• http://www.dexigner.com/design_news/2482.html

• http://skyscraperpage.com/cities/?buildingID=8368

• http://www.turningtorso.com/html/faq_en.htm

• http://www.designbuild-network.com/projects/turning-torso/

• http://en.wikipedia.org/wiki/Turning_Torso

**thank you**

**team**

charul mehta

jeremy harper

nupur gupta

thomas oomen