Capstone Design

NEW UNITED CENTER ARENA
Design

- New arena for hockey and basketball:
  - Structure
    - Sitting area
    - Arena
  - Parking
    - Underground
    - Above level
    - On the ground
  - M.E.P design
    - HVAC
    - Lighting
    - Acoustics
ARCHITECTURAL CONCEPT

• Indoor arena and Outdoor arena
  o Different activities can be performed in the different arenas. (Outdoor concerts in summer, Soccer games on the grass...)
  o Flexibility: area for other sports, exhibitions or any other activity in the future.
  o Permanent use of the building. Sport museum, conference rooms, games area as exhibition area...
  o Games grass area can be outside

• Improvement of the surroundings of the arena.
  o The arena is surrounded by gardens instead of concrete parking lots only used when there are games.

• Landscape + Parking
  o Improve the large area of parking around the United center and convert it into landscape parking design
First ideas
Munich. Soccer Stadium

Arizona. Stadium

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Other references: sections of stadiums

Millenium dome

Wembley stadium
Arenas and parking layout
Section A-A
Facades: longitudinal and transversal
Exterior

- Structure limit: the glass
  - Roof like floating above the glass
- Metal
  - Lightness and shiny point that catch the attention of the coming public
- Round shape
  - The roof as the cover of the space.
  - Higher in the game area.
Roof material

Insulation sandwiched between two layers of metal.

We use metal because it is impermeable and very light.
Interior

- Structure away from the sitting area
  - Not interrupted visibility
- Trusses
  - Light structure that permits to see the large roof
- Steepness of the sitting area
  - Enable to see from every point of the sitting area
Landscape parking

- Green roof
  - Better thermal performance

- Natural Light and Ventilation
  - Cleaner air and better light

- Parking as a garden
  - Integrated solution
THE LANDSCAPE PARKING
The parking garage was envisioned like gardens with glass entrances. The waves have a phase so they permit to open entrances to the parking
ARENA STRUCTURE
Arena Structure

- **Roof Truss**
  - A 3-dimensional triangular truss
  - Made of structural steel that includes W-sections and HSS pipes
  - Truss spans approximately 380 feet
  - Trusses take load from prefabricated steel roof joists
  - Middle truss supports the 56,000 pound Jumbotron
Arena Structure, ctd...

- An isometric view of the truss
Arena Structure, ctd...

- A typical connection detail
Arena Structure, ctd...

- An illustration of steel roof joists
Arena Structure, ctd...

- The United Center Jumbotron
Arena Structure, ctd...

- Isometric view of seating area structure
Arena Structure, ctd...

- **Seating Area**
  - Frames are constructed out of steel W-sections
  - Moment resisting frame is used in the radial direction to resist lateral loads due to occupants
  - Braced frame is used in the tangential direction to resist lateral loads due to occupants
  - Outer seating area columns support the roof system
  - Seats are supported on prestressed, prefabricated, hollow core concrete slabs
  - Concrete slabs are supported on rakers belonging to the supporting girder
  - Wind loads are transferred to shear walls which house the elevators and the stairs
Arena Structure, ctd...

- An illustration of steel rakers
Arena Structure, ctd...

- An illustration of pre-cast, pre-stressed hollow core beams
Arena Structure, ctd...

- An illustration of a shear wall. Note the connection of the structure to the wall
## Arena Structure, ctd...

- **Foundation and Floors**
  - The stadium playing floor is cast-in-place reinforced concrete.
  - The floors for the walking area are reinforced concrete on metal decking making a composite beam effect with the W-sections.
  - The foundation will be a series of isolated spread footings.
Arena Structure, ctd...

- An illustration of composite beam
Arena Structure, ctd...

- An illustration of spread footings
Arena Structure, ctd...

- Miscellaneous
  - The structure was drawn up in AutoCAD 2006 and transferred to SAP2000 for load analysis
  - ASCE 7-02 was used for determining the loads acting on the structure
  - The triangular roof truss is not the most efficient design but is aesthetically pleasing to the viewer
PARKING DESIGN
Design

• Front view of the parking structure

• Rear view of the parking structure
• Above ground parking.
• 4 levels
• Top most parking is VIP
• First three levels have 500 parking spots each.
• Top level 300 spots.

• Internal supports every 5 spaces
• On the exterior barriers to hold cars back
• Skeleton of the ramps
ABOVE GROUND

• VIP exit from the fourth floor.
• Accessibility only by VIP ticket holders

• Entrance and exit to the first floor of parking structure.
TAXI and BUSSES

- Parking for busses and taxis
- Roof member
- Above ground
- Busses Space
GREEN ROOF

- Roof on top of a underground parking
- Promoting green roof effect

Top view of the parking under each wave
- 44 parking spots each
- Entrances on the side and underground
UNDERGROUND PARKING

- Side view of underground.
- Ramps going down and up

- View of parking under ground
- Beam supports going down
- Walls for underground
UNDERGROUND PARKING

• Under ground parking
• Better view of green roof parking

• Steel Metals on the back wall
• Concrete between ridges
• More lighting
BRIDGE

- Bridge from forth floor parking into the arena
- Strictly VIP ticketed holders
- Supported from each side of the road
BRIDGE DIAGRAM (LONG)

- Deformation of the bridge
- Analysis showing distributed loads
BRIDGE DIAGRAM (SHORT)

- Deformation of the bridge
- Analysis showing distributed loads
- Bridge calculation of 78.29 lb/ft\(^3\)

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PROMOTING GREEN

- Converting a parking lot.
- Helping improve the environment
M.E.P DESIGN
Acoustics

- Reverberation Time in Corridors
  - Perceived as the time for sound to die away
  - Shorter time = better
  - Result ranges from .3 to 1.38 sec.
  - Drop Acoustical Ceiling Tile
HVAC Graphs
Third Floor
Graph of Total Heating Coil Load (Btu/hr) Vs Hours

Hours:
0 5 10 15 20 25 30

Total Heating Coil Load:
0 50000 100000 150000 200000 250000 300000 350000 400000

Third Floor
Conference Room
Conference Room

Graph of Room Total Heating Load (Btu/hr) Vs Hours

-35000 -30000 -25000 -20000 -15000 -10000 -5000 0 5 10 15 20 25 30

Room Tot Heating Load

Hours
Graph of Latent Heating Coil Load (Btu/hr) Vs Hours
Conference Room
LIGHTING OBJECTIVE

Arena Bowl Lighting
Control the brightness of an object versus the background such that the object will be visible regardless of its size, location, path and velocity, for any normal viewing position of spectator or player.
LIGHTING DESIGN SECTIONS

• Arena Bowl Lighting
• Specialty Rooms
  o Skyboxes
  o Suites
• Bathrooms and Player Locker Rooms
• Concession Stands
• Public Walkways
ARENA BOWL LIGHTING

- Event Lighting Systems
- House / Aisle / Emergency Lighting
- Theatrical Effects
- Scoreboard / Score cube
- Miscellaneous
  - Portable Spotlights
  - Still Camera Strobes
  - Catwalk
DESIGN CONSIDERATIONS

- Power Input Required
- Control Systems
- Event Lighting
  - Light Sources
  - Light Fixtures
  - Instant On / Off
DESIGN RESOURCES

• Technical Magazines
• Professional Society Publications
  o Illumination Engineering Society of North America
  o International Commission on Illumination
• Internet
• Professional Consultants
• Manufacturing Representatives
DESIGN RESULTS

Event Lighting System

- GE Ultra Sport Quadrant System
  - 200 Total Lamps
  - 2000 / 1000 Watt
  - 0%-50%-100% Automatic Dimming
  - 200-footcandles on playing surface
- 400-Watt Retractable Twin Luminaire
  - 75-footcandles on playing surface
DESIGN RESULTS

House / Aisle / Emergency
Instant on source of general illumination
Within arena bowl. Alternately powered by emergency power generator
- 500 Watt Suspended Tungsten Halogen
  - 25-foot candle illumination.
- LED Aisle Lighting
- Full Brightness Emergency Lamps
  - Located at all exits
DESIGN RESULTS

- Specialty Rooms
  - Halogen ceiling lights with additional task lighting
  - Minimum illumination of 40-foot candles
- Public Room / Bathroom
  - Fluorescent lighting
  - Minimum illumination of 30-foot candles
- Recommend 4 spotlights with 12 optional locations
Plumbing

- Two taps from City Main
- Determine Flow Rate in GPM
- Size System
- Waste Stacks and Vents
- Follow Code