Sustainable sport venue design

P5 presentation – Felix Dorst

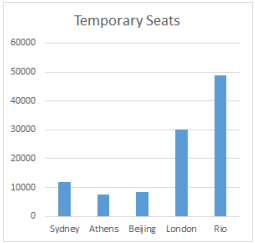
10-4-2018

Olympic legacy

Athens Olympics
2004

Beijing Olympics
2008

Temporary Olympic venues



Rio Olympics 2016

Pyongyang Winter Olympics 2018

Problem statement

Olympic venues have a reputation to leave a bad legacy

Temporary venues are increasingly common

Venues consists mostly of load bearing structure and facade, and almost exlusively built from steel

Temporary venues use a lot of material in a short amount of time

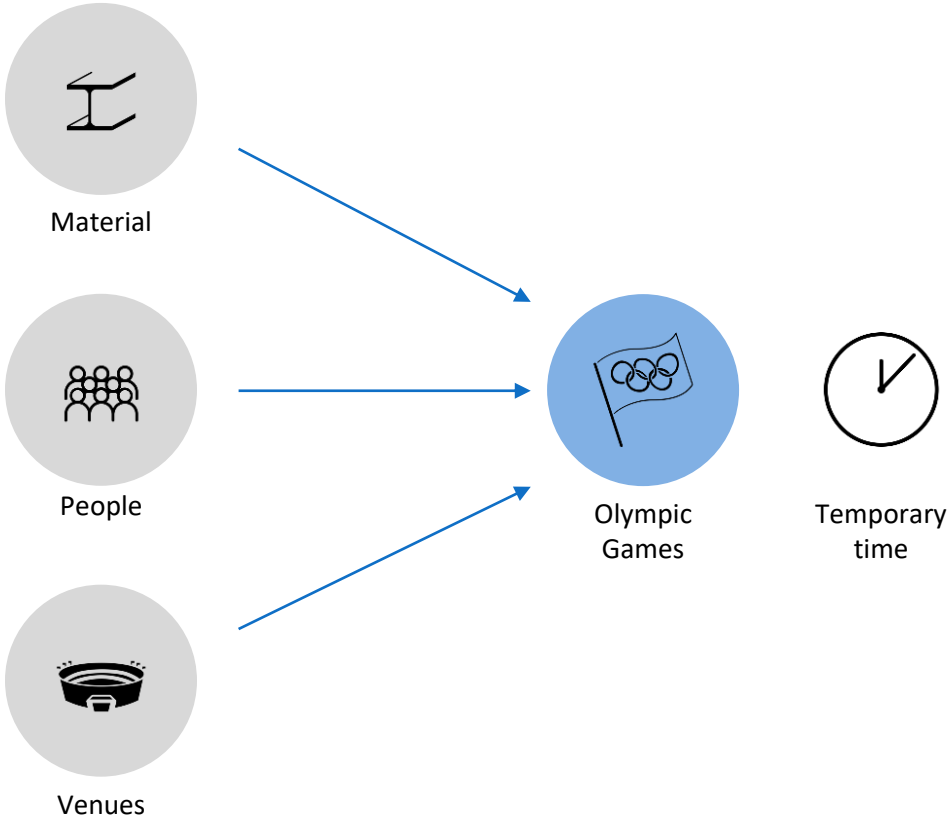
Research question

How can a **design strategy** for a **temporary and demountable** sports arena for the Olympic Games be optimized to a **post-event use** in **steel construction**?

Literature

1 Legacy
2 Post-event uses
3 Demountable
4 Conclusions

Legacy Olympics



Post-event uses of sport venues venues

1 Relocate

2 Adapt

1 Upcycle

1 Recycle

Basketball London

Aqua centre Rio

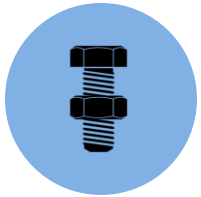
Water polo London

Sydney Olympics

Post-event uses unexpected outcome

Venue	Intended post event use	Succes?	Actual legacy
 Aqua centre Rio 2016	Transformation to 4 schools	✗	- Abandoned - Too expensive - One strategy
 Basketball London 2012	Relocate as travelling arena	✗	- Disassembled - Never used again - One strategy
 Olympic stadium London 2012	Reduce size & upcycle	✓ ✗	- Reduced in size - No record of upcycled elements - Multiple strategies

Disassembly & transportation



Demountable

Minimize *number of tools*

Minimize *number of tasks*

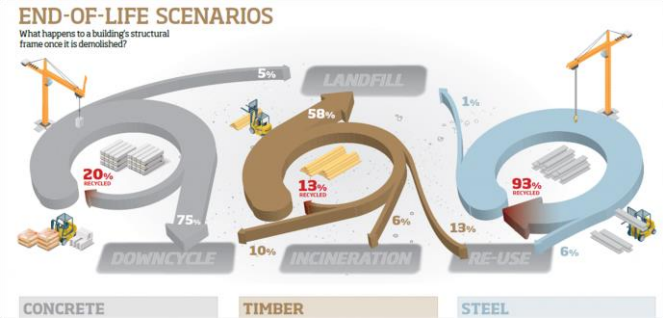
Minimize *time to disassemble*

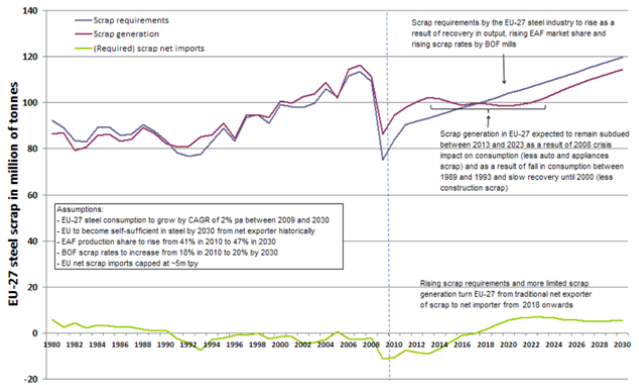
Circular economy of steel construction

Steel is the most suitable
- Standardization is possible
- Weight/strength ratio
- much potential

barriers of steel
- Likely to be recycled
- Lack of documentation
- Not enough standardization

- increasing value of scrap steel





Conclusions literature

- There are **four** possible **post-event strategies** to **reuse** a temporary sports arena
- Selecting a **single** type of strategy has a **low rate of success**
- **Demountability** of venues and **transport** are essential factors to **reuse** a temporary sports arena

Requirements

1 Design focus
2 Structural requirements
3 Reuse strategy

Design focus

Apply findings to case

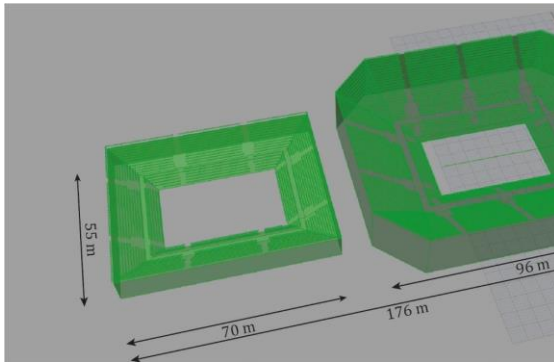
- Volleyball arena Paris Olympics 2024

General requirements

- Capacity for 17.000 and 5.500 visitors in one volume (Seating bowl shape)
- Enclosed from wind, rain and direct sunlight, column-less space

Design focus

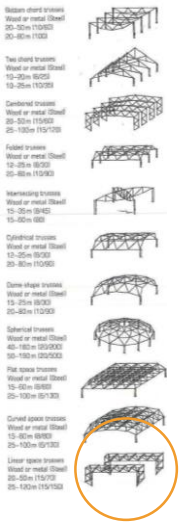
- Volume design, general shape
- Steel load bearing structure

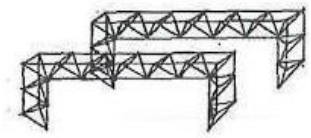


Structure requirements

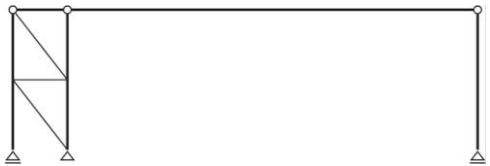
- Simple structure > determined by research from case studies
- **Demountable :** Bolted steel connections
- Optimized towards reuse
- Form follows function: shape is formed by the construction

Structure portal construction





Portal construction: Linear space trusses



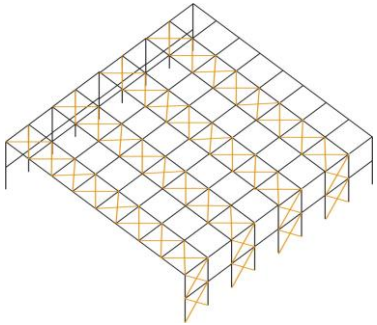
*Portal construction (**shear** connection)*

- More material & footprint
- Simpler connection
- Simple disassembly

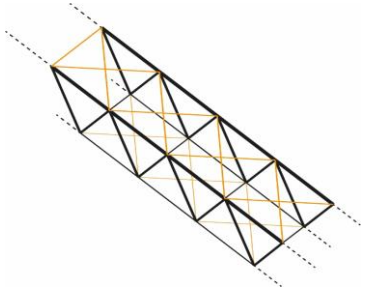
*Portal construction (**moment** connection)*

- Less material & footprint
- Complicated connection
- Difficult disassembly

Structure roof construction

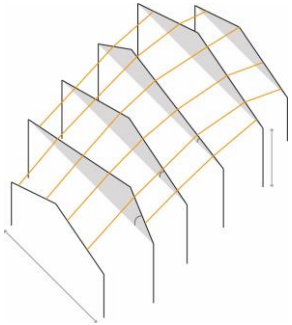


Stability every other portal construction…



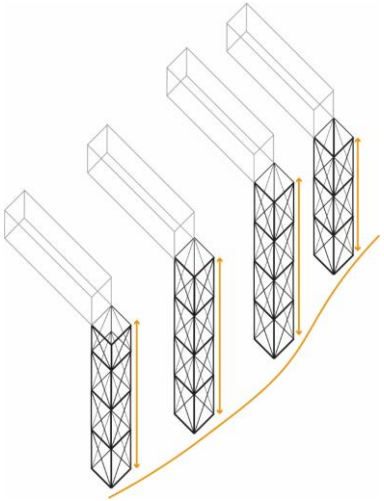
... leads to connected trusses (space trusses)

Slanted roof: alternating angled trusses

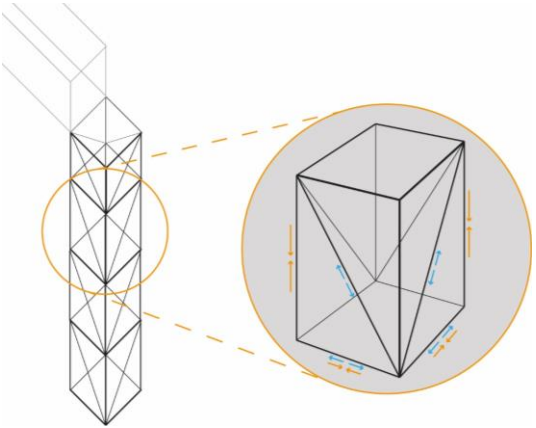


Spacers

Structure column construction

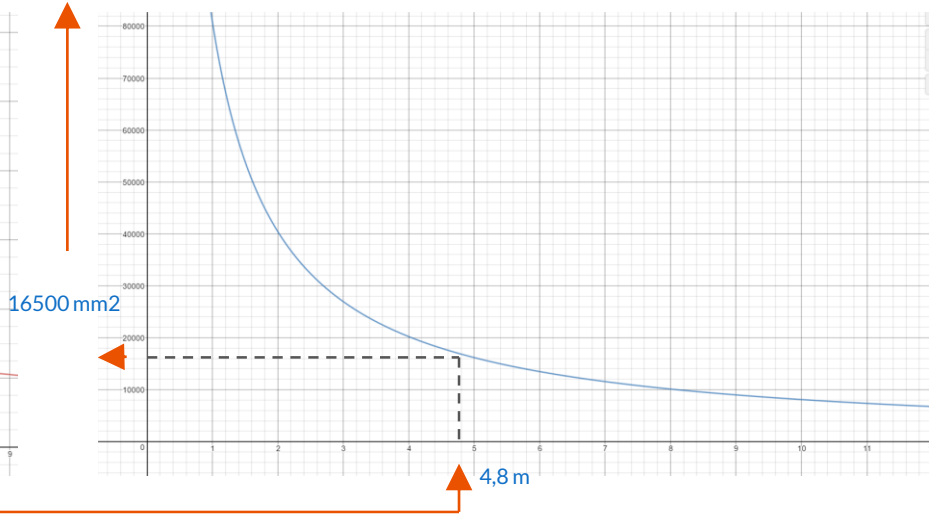


Alternating heights, and irragular placement



Modular built trusses, interchangable and repeatable

Structure hand calculations



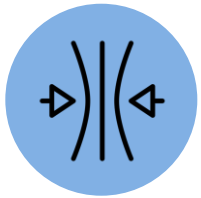
Height of the roof construction (x) plotted against the deflection (y)

Height of the roof construction (x) plotted against the profile surface area (y)

Post-event strategy

1 Relocate

a. *whole*
b. *transformed*



2 Adapt

to other building formats

3 Upcycle

construction into reusable members

4 Recycle

as little as possible

Design requirements

Relocate whole - requirements

Relocate

Demountable

Technical elaboration:

*- **Minimizes** number of tools*

*- **Minimizes** number of tasks*

*- **Minimizes** time to disassemble*

Transportable

Transport restrictions of shipping container:

Maximum element dimensions:

Height:	*2,59 m*
Width:	*2,44 m*
Length:	*12,19 m*

Transport restrictions of road transport:

Weight limit of element:

Weight:	*40 t*

Design requirements

Demountable

Transportable

Relocate & transform - requirements

Relocate & transform

Duplicate members

Technical elaboration

- *Standardized profiles*
- *Standardized connections*
- *Similar measurements*

Adaptable component use

Connections

- *Interchangable*
- *Alternative configurations*

Documentation of components

Database containing:

- *Member dimensions*
- *Member categorization*
- *Connection method*

Parametric environment

Design requirements

Demountable

Transportable

Parametric environment

Adapt to other building format - requirements

Adapt to other Building format

Building formats

Simplification of 3 building formats

- *Portal construction*
- *High rise construction*
- *Truss construction*

Containing

- *Dimensions*
- *Connection method*
- *Common profiles*

Adaptable connections

Connections

- *Multi-angled connections*

Adjust geometry accordingly

Input data:

- *For example: Commercial floor hight 4,2 m*
- *Multiples of*
- *Generalize towards standard measurements (1m)*

Parametric environment

Design requirements

Demountable

Transportable

Parametric environment

building format requirements

Upcycle - requirements

Upcycle

Documentation of components

Database containing:

- *Member dimensions*
- *Member categorization*
- *Connection method*
- ***Physical adjustments***
- ***Repetition***

Visual tool

Design requirements

Demountable

Transportable

Parametric environment

Building format requirements

Reusable members

Visual tool

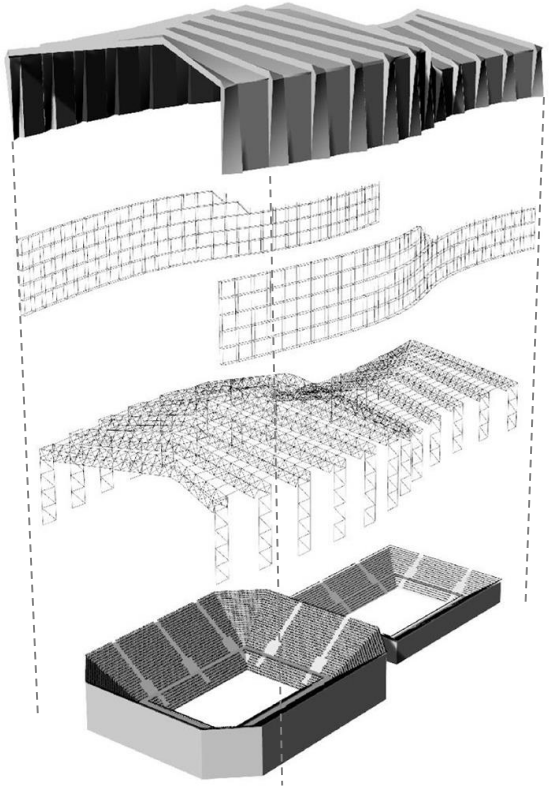
Conclusions

-
- Selecting a **single** type of strategy has a **low rate of success**
- **Demountability** of venues and **transport** are essential factors to **reuse** a temporary sports arena

Design

1 Validation method
2 Design overview
3 Technical elaboration
4 Parametric?? nope
5 Results

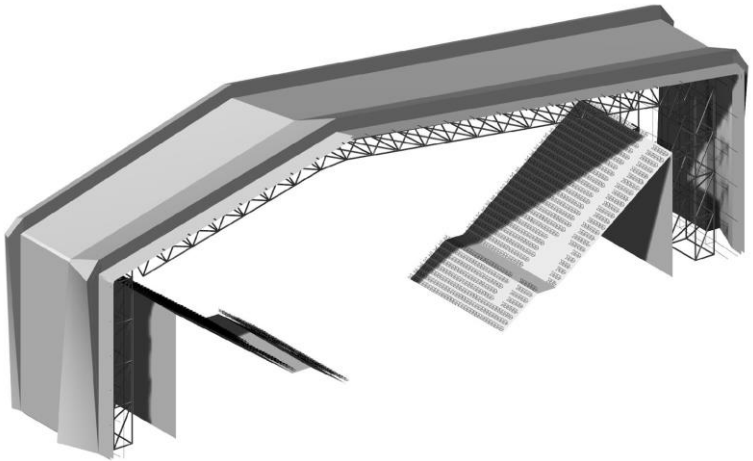
Design overview

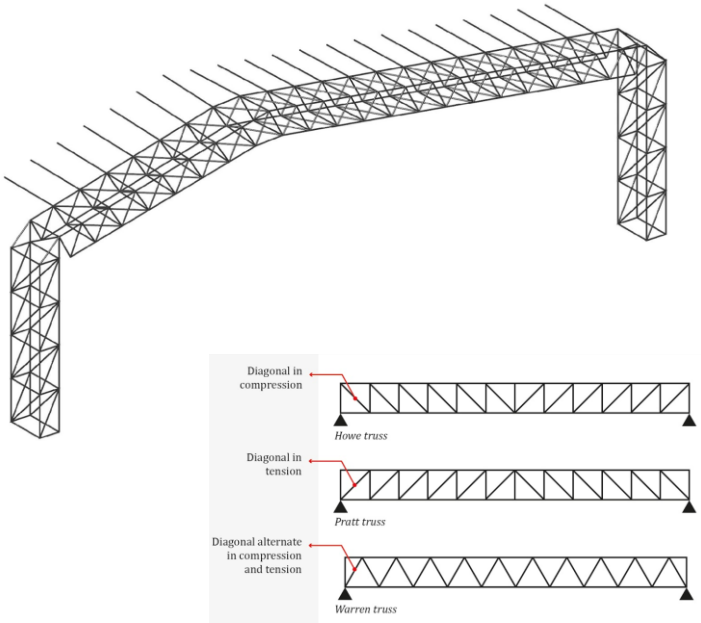


- Façade – PVC membrane
- Steel load bearing construction
- Temporary seating Bowl 13.000 + 5500 capacity

Design implications

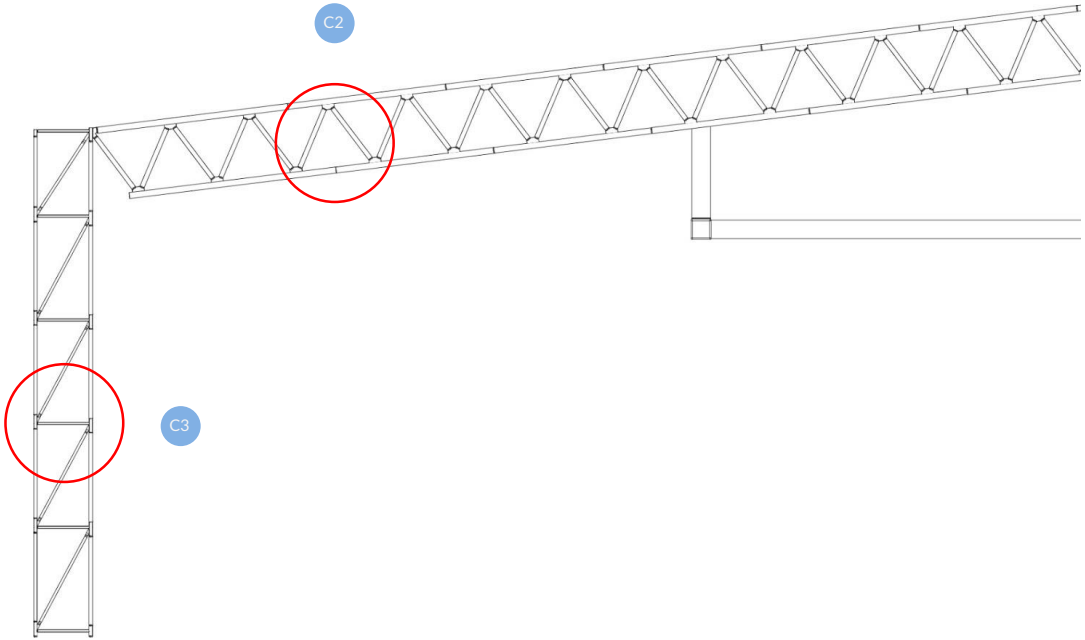
Design construction

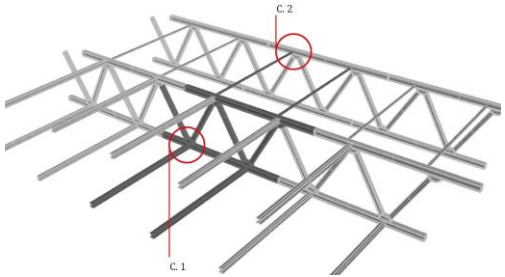


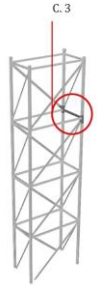


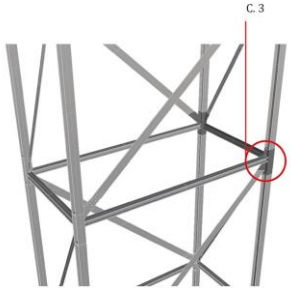
Design implications

Design construction



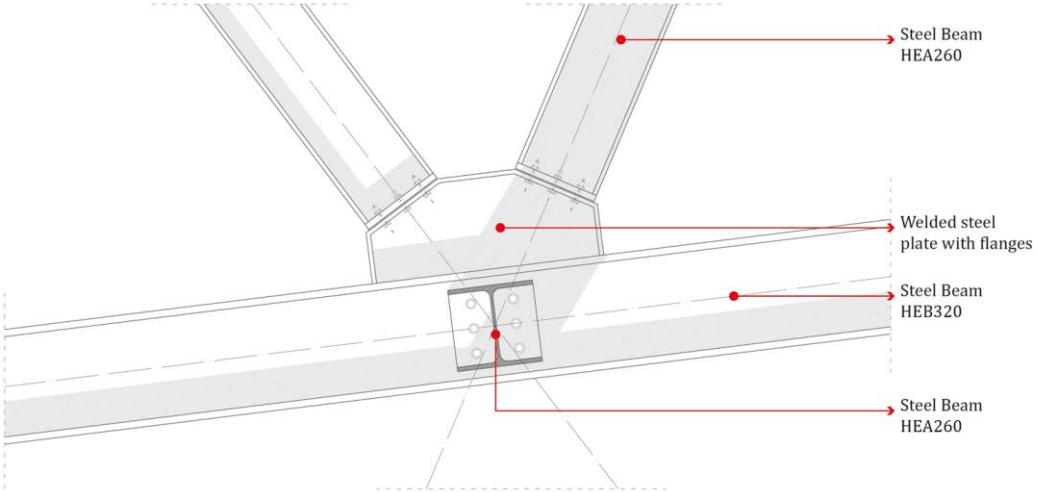


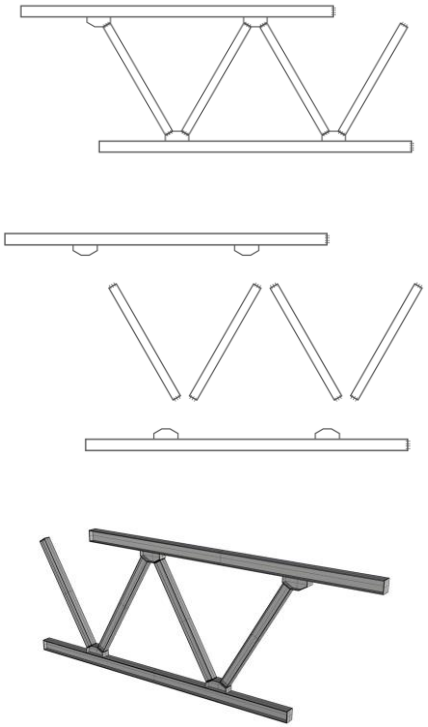




Design implications

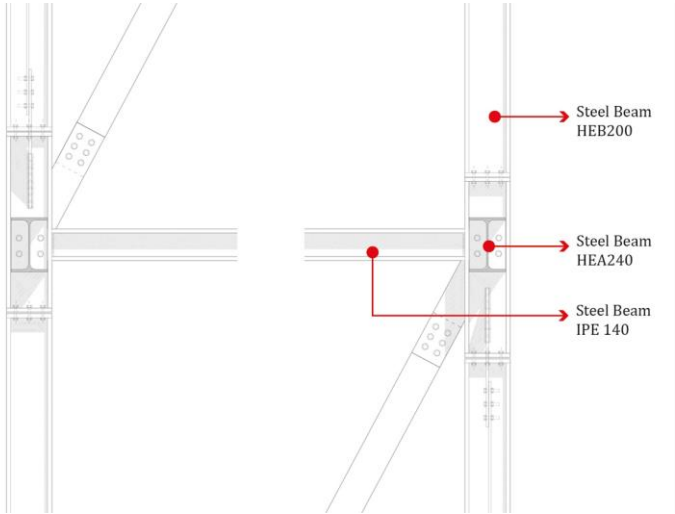
Design construction

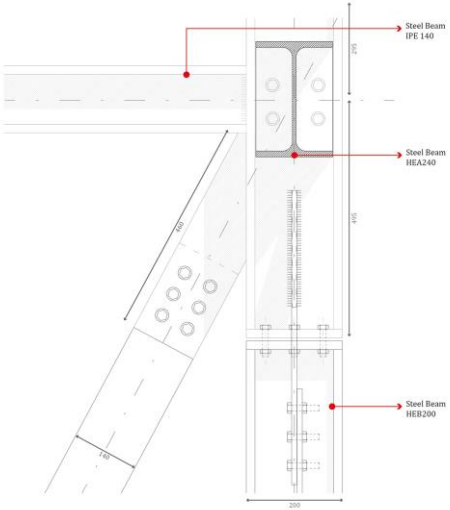


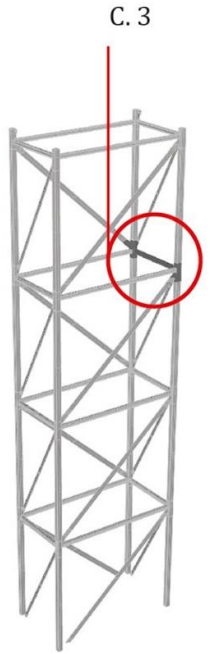


Design implications

Design construction

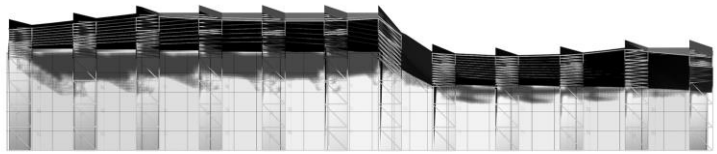


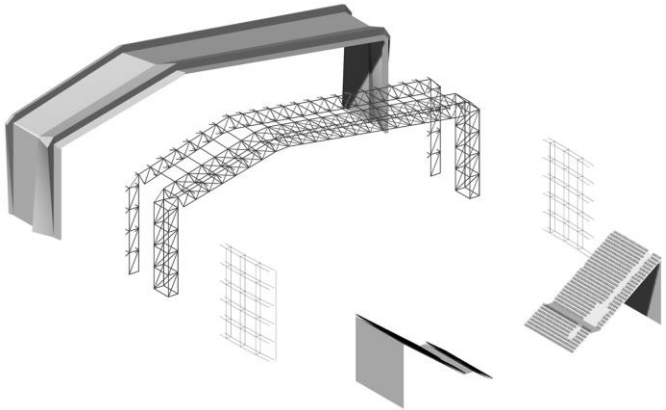




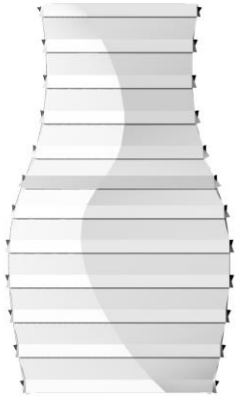
Design implications

Design facade





- Façade – PVC membrane
- Steel load bearing construction
- Scaffolding
- Seating bowl



Design implications

Research by design

1 Relocate *2 Adapt* *3 Upcycle* *4 Recycle*

Design requirements

Validation Relocate & transform

- We need to know:
- Database on members in the structure
    - Member length
      Type of member (category)
      connection

- Exact info of three rearranged iterations of the design
- A way to compare those with the original

Design implications

Demountable

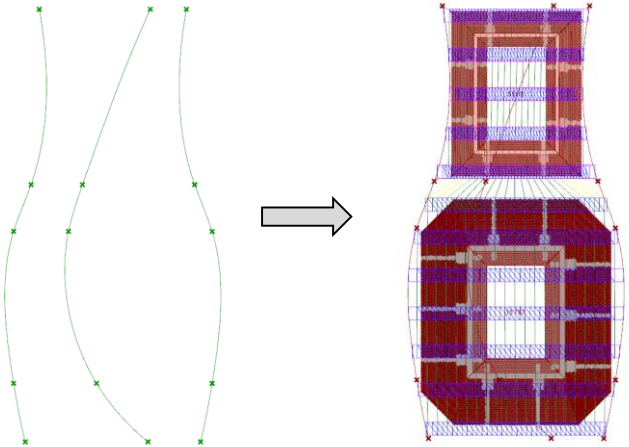
Lightweight

Parametric environment

Validation Relocate & transform

Input:

- Dimensions LxWxH
- Shape (curved)



Output:

- Altered shape towards standardization
- required construction density & height

Design implications

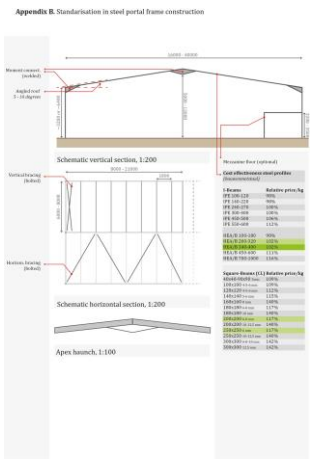
Demountable

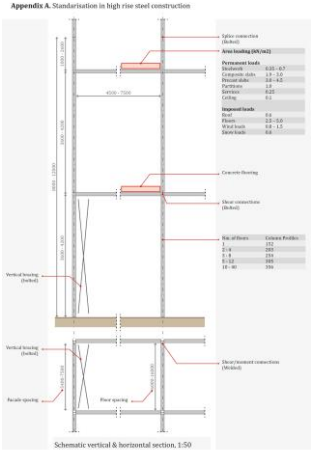
Lightweight

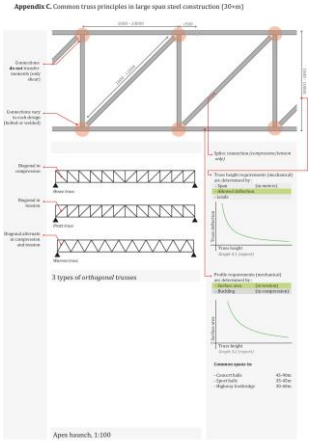
Parametric environment

Validation Adapt to other building format

- Steel portal construction (supermarket etc.)
- High rise construction (offices etc.)
- Steel truss (Concert hall etc.)







Design implications

Demountable

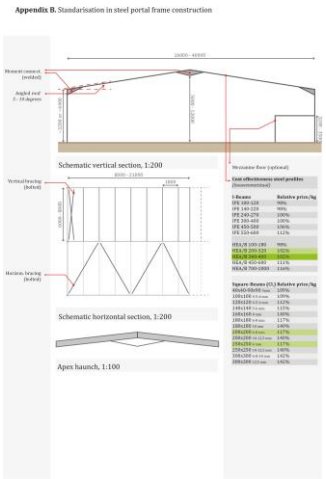
Lightweight

Parametric environment

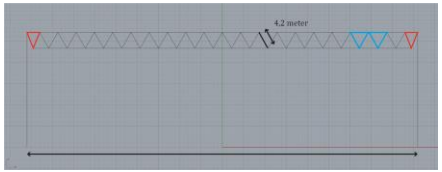
building format requirements

Validation Adapt to steel portal construction

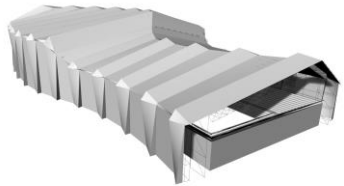
1 Research



2 Implication on design

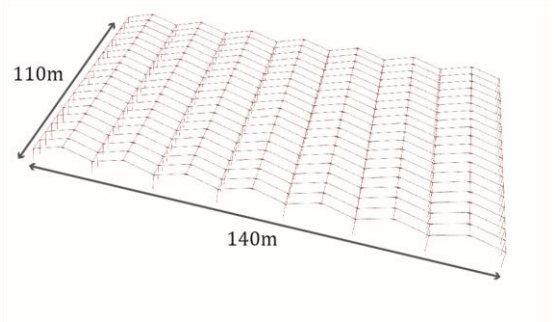


3 Design



4 Post event use

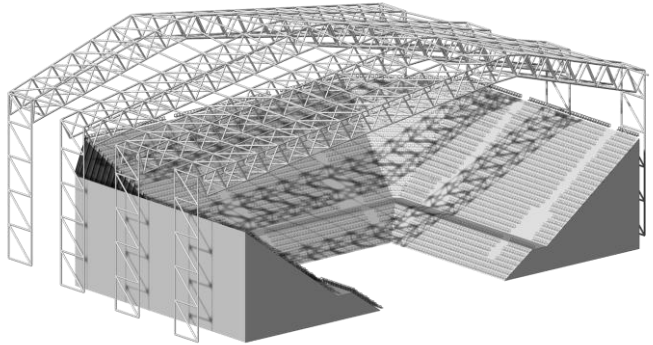
(34% of the steel reused)



Design implications

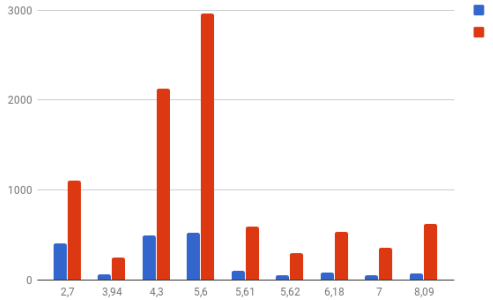
Demountable | Lightweight | Parametric environment | building format requirements

Validation Upcycle



- Similar members (count > 50)
- Required alterations on member
- Visual tool

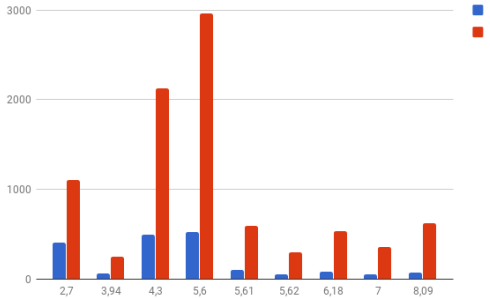
No physical adjustments	- Cleaning/removing residue - Removing coatings/paint - Applying new coating/paint	Likely to reuse
Physical adjustments	- Additional connection holes (drilling) - Cutting element to size - Cutting connections ends	Possible to reuse
	- Removing reinforcment steel plates (cutting) - Connecting new elements (welding) - Filling holes	Unlikely to reuse
	- Repairing damaged elements - Increasing length (welding)	Impossible to reuse



Design implications

Demountable | Lightweight | Parametric environment | Building format requirements | Reusable members | Visual tool

Validation Upcycle similar members



Count boundary	Member length	Count	Combined length
>50	2.7 m	410	1107 m
>50	3.94 m	64	252.16 m
>50	4.3 m	494	21242 m
>50	5.6 m	529	2962.4 m
... etc. (5 more)	... etc.	... etc.	... etc.
Total			8849.69 m
<50	0.34 m	2	0.68 m
<50	0.54 m	2	1.08 m
<50	0.57 m	2	1.14 m
<50	0.61 m	2	1.22 m
... etc. (332 more)	... etc.	... etc.	... etc.
Total			8566.86 m
Percentage (count =50>) in meters steel fit for upcycling			**53.9% (in m)**

Design implications

Demountable

Lightweight

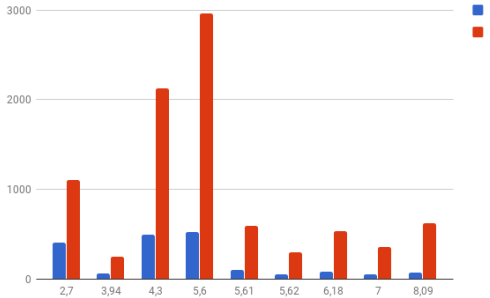
Parametric environment

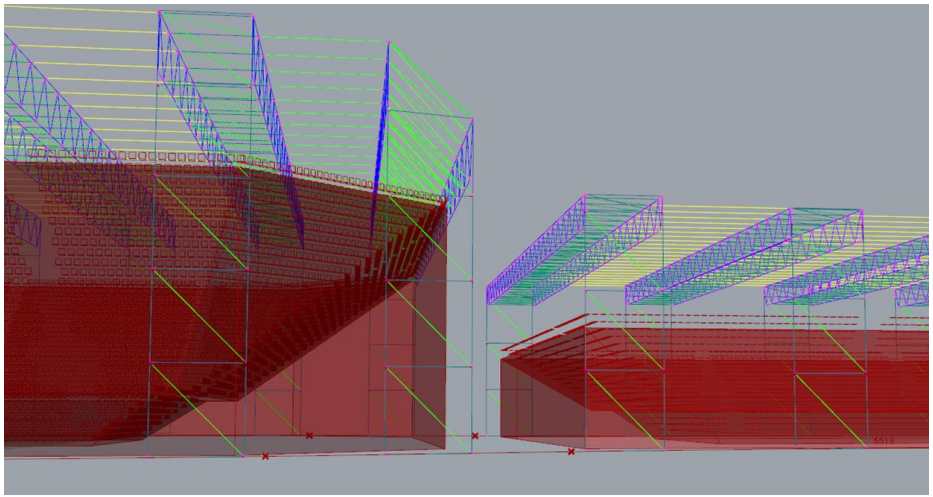
Building format requirements

Reusable members

Visual tool

Validation Upcycle visual tool





Design implications

Demountable

Lightweight

Parametric environment

Building format requirements

Reusable members

Visual tool

Conclusions

How can a **design strategy** for a **temporary and demountable** sports arena for the Olympic Games be optimized to a **post-event use** in **steel construction**?

Design implications

Conclusions

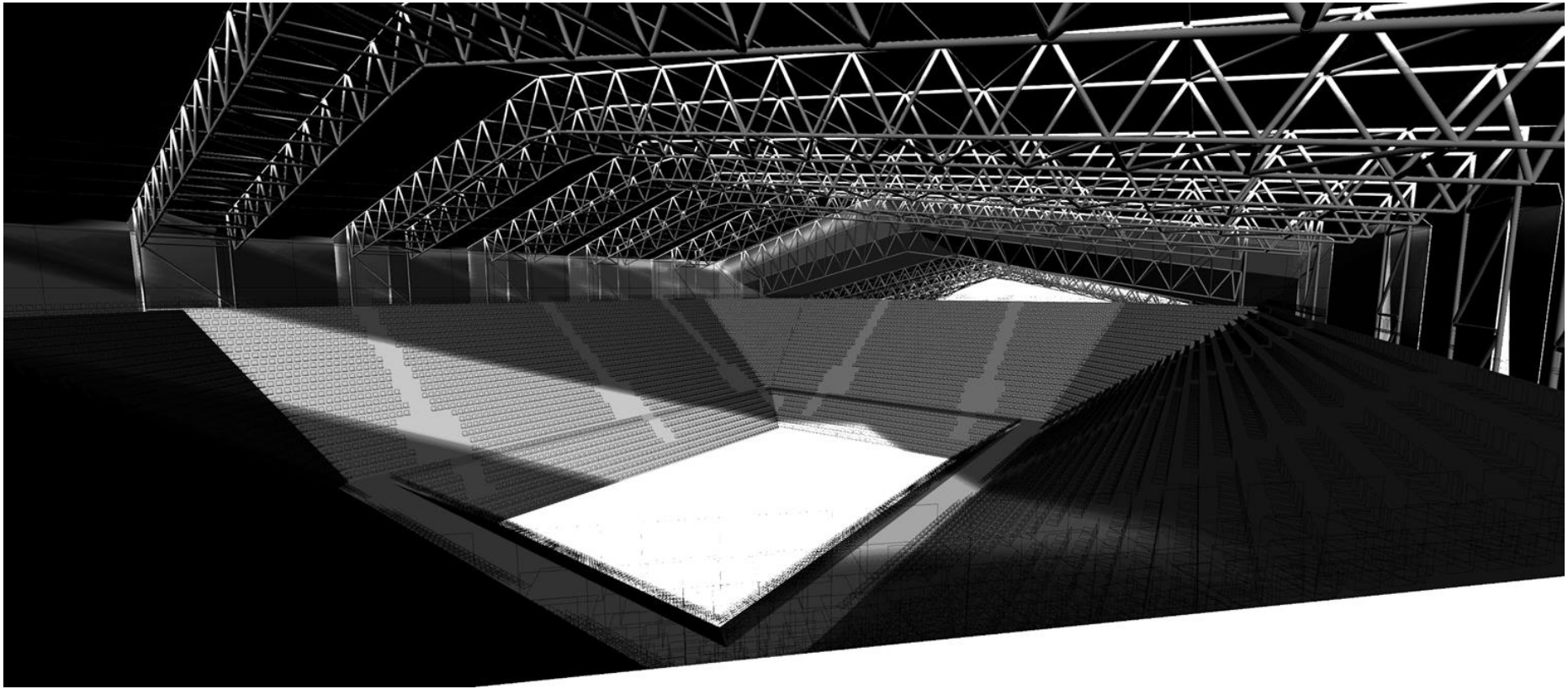
- Account for multiple scenarios of reuse: Relocate, Adapt, Upcycle and recycle
- Design decisions must be be based on information from the steel construction industry
- Computational tools and documentation must be used to guide the design process and to assess the influence of design decisions

Design implications

Conclusions further recommendations

- A computational and parametric design lends itself for further optimization
- Location specific demands could help to embed the reuse strategies

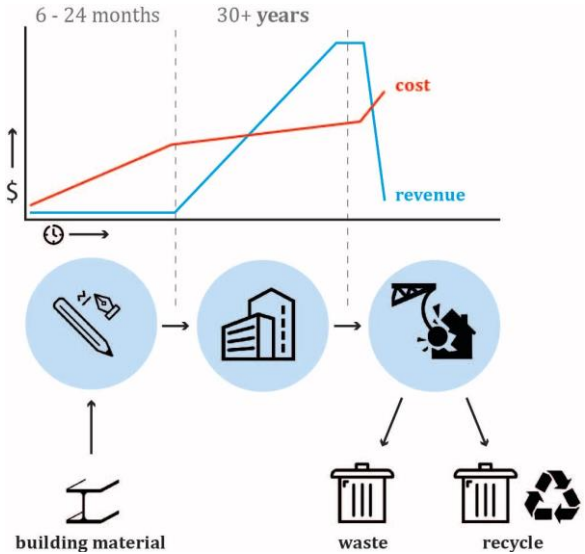
Design implications



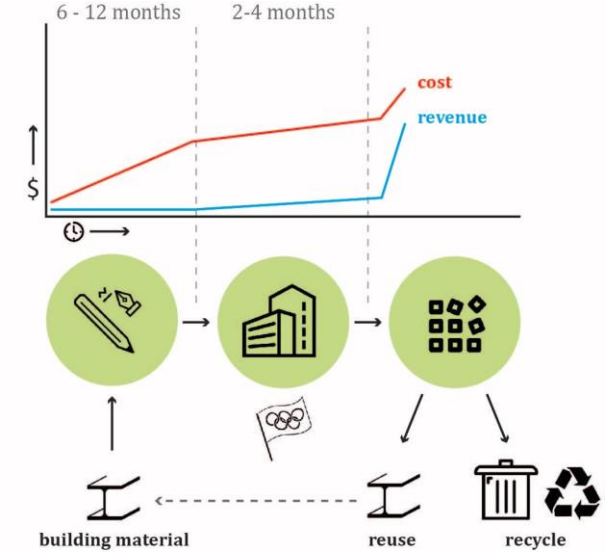
Thank you!

Sustainable sport venue design - Felix Dorst

Reuse requirements goals



Traditional building revenue



Required building revenue