Gathering21
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CitA

BIM-based parametric adaptive design of kinetic shell facades in buildings

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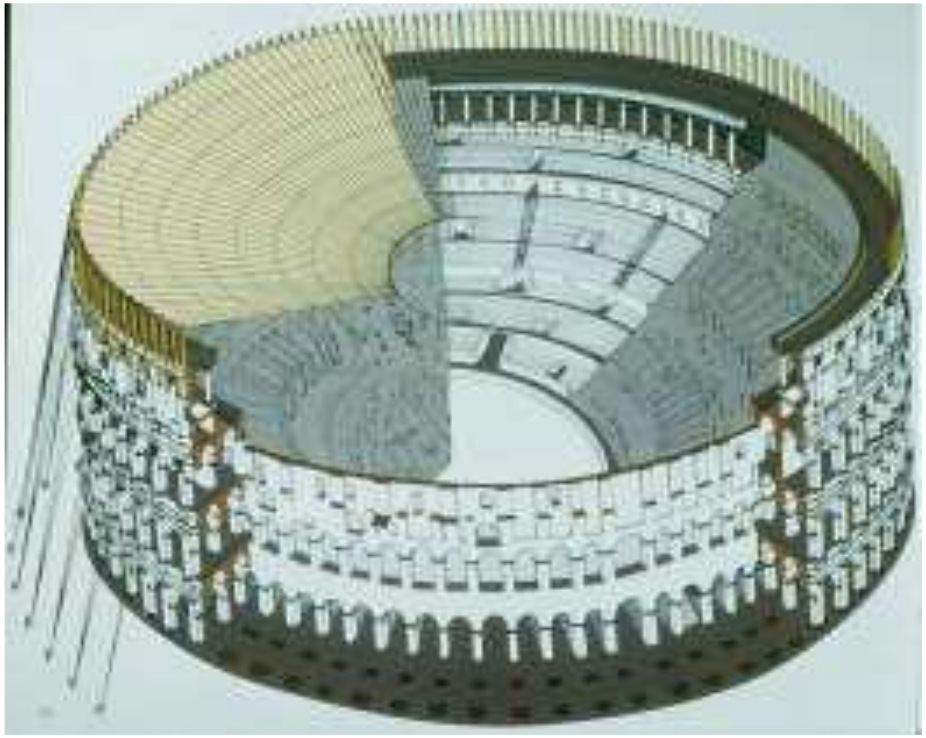
- Adaptive Architecture
- A BIM-based parametric workflow to design and test adaptive kinetic façades

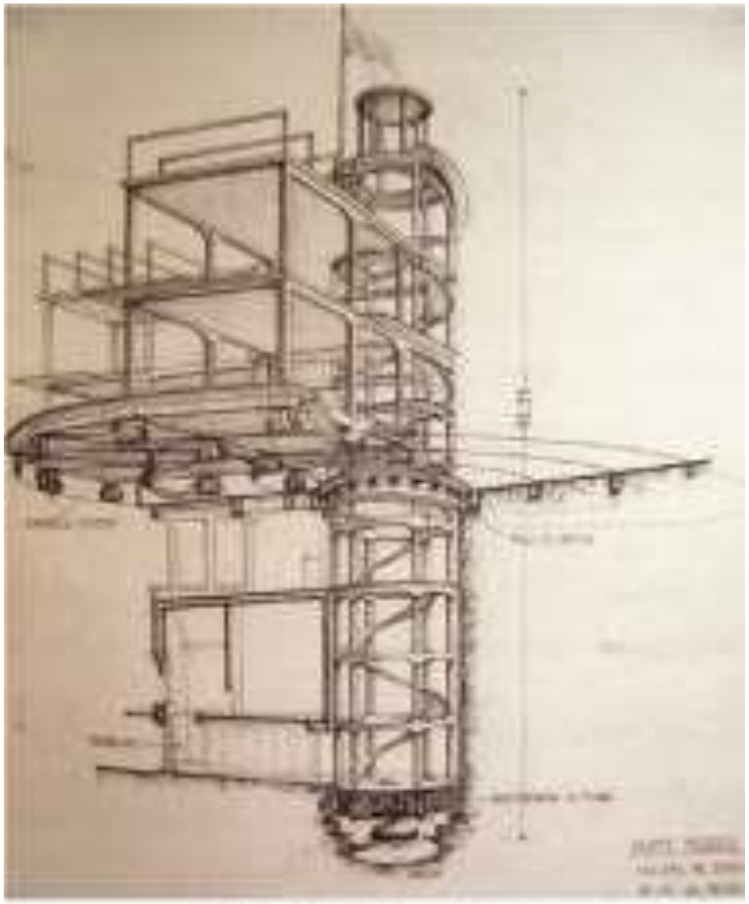
Visual representation of the Roman Colosseum Roof system.
Courtesy of: bewminate.com, 2017.



Fort of Ponta da Bandeira Drawbridge, Portugal.
Geroges Jansoone, Self-photographed, 2006.

Villa Girasole, Marcellise VR, Italy..
Courtesy of: casa.it.

Gears and mechanical revolving system
Courtesy of: skolnick.com



Examples of Buildings with Kinetic façade systems

Building Name	Location	Year built	Purpose of façade
Arab Institute	Paris, France	1987	NLC**
Nordic Embassies	Berlin, Germany	1999	NLC
Council House 2	Melbourne, Australia	2006	SRP**, NLC
Al Bahar Towers	Abu-Dhabi, U.A.E.	2012	SRP
Dubai Apple Store	Dubai, U.A.E.	2017	SRP, NLC

**NLC → Natural Light Control
SRP → Solar Radiation Protection

The Arab World Institute visual
Courtesy of: www.as.architecture-studio.com

The Mashrabiya Diaphragms Used for The Façade
Courtesy of: www.new-hotel.com

Circular Shaped Diaphragm

Square Shaped Diaphragm

8 Points Star Shaped Diaphragm

Courtesy of: https://www.imarabe.org/en/architecture

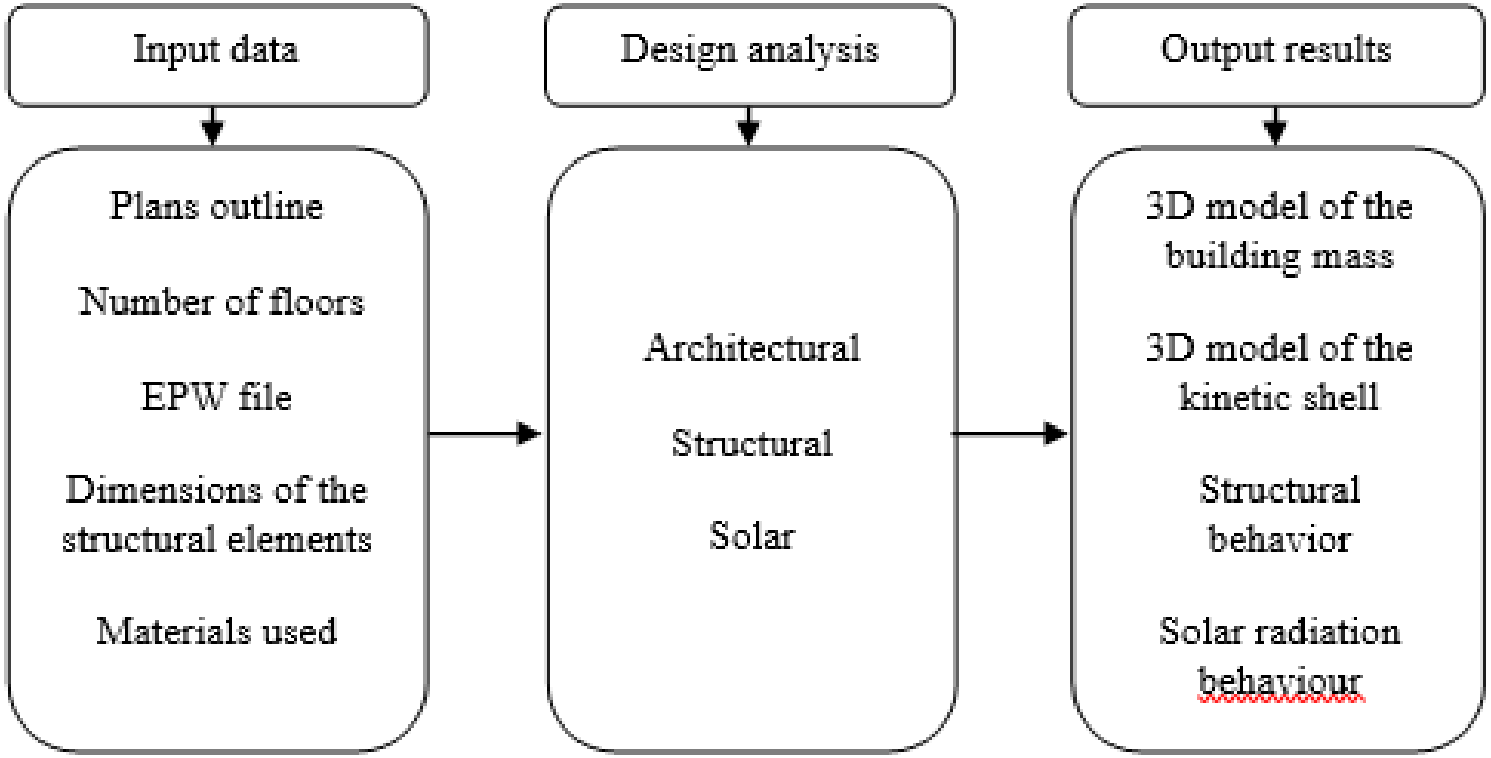
Background

Nordic Embassies, Berlin
Green Cladding wall louvres motion
Courtesy of Lucas Gray, talkitect.com, 2008

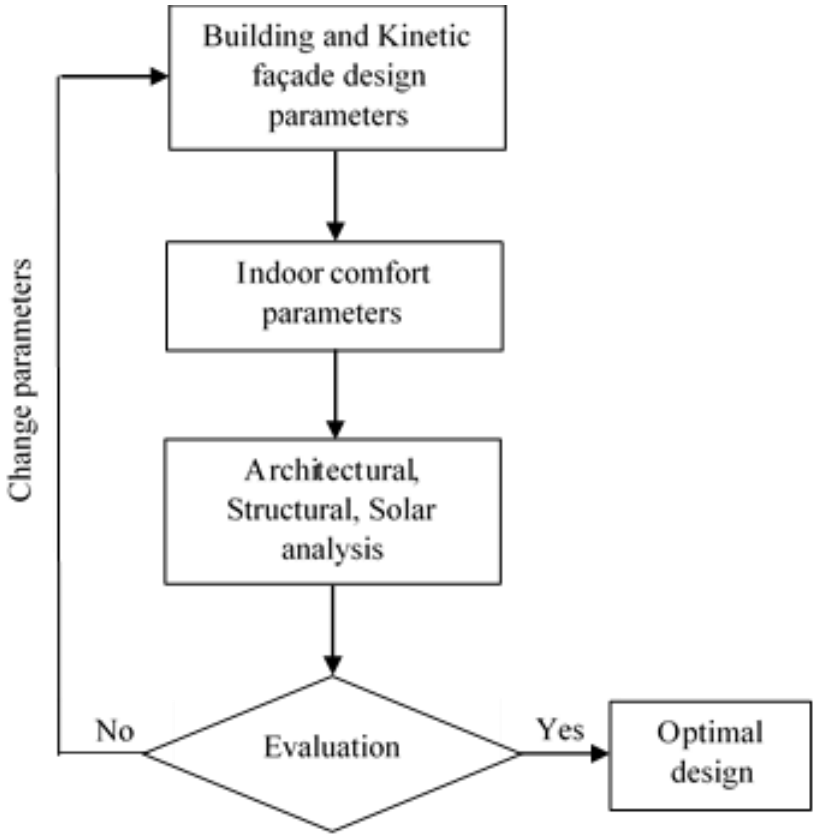
Al Bahar Towers Daytime View
Courtesy of: aedas.com

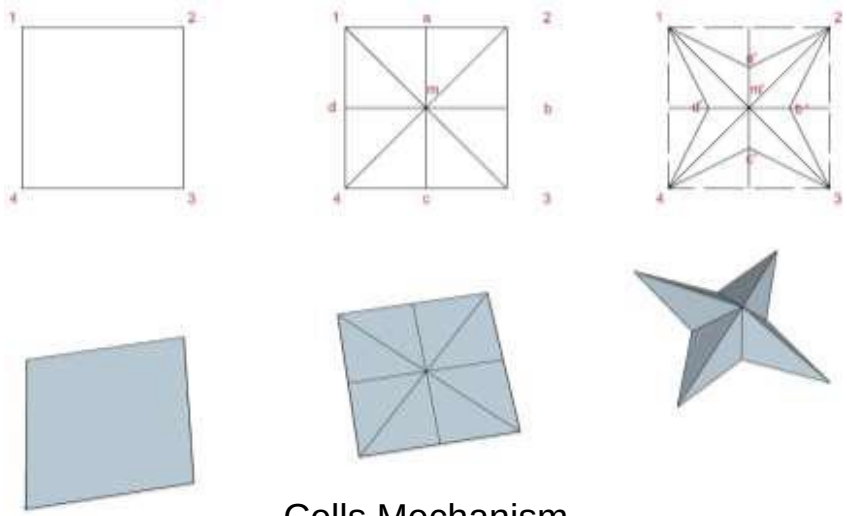
The Shutters on The Western Kinetic Façade System in CH2
Courtesy of the official governmental website of the City of Melbourne, Australia, [Online].

Methodology

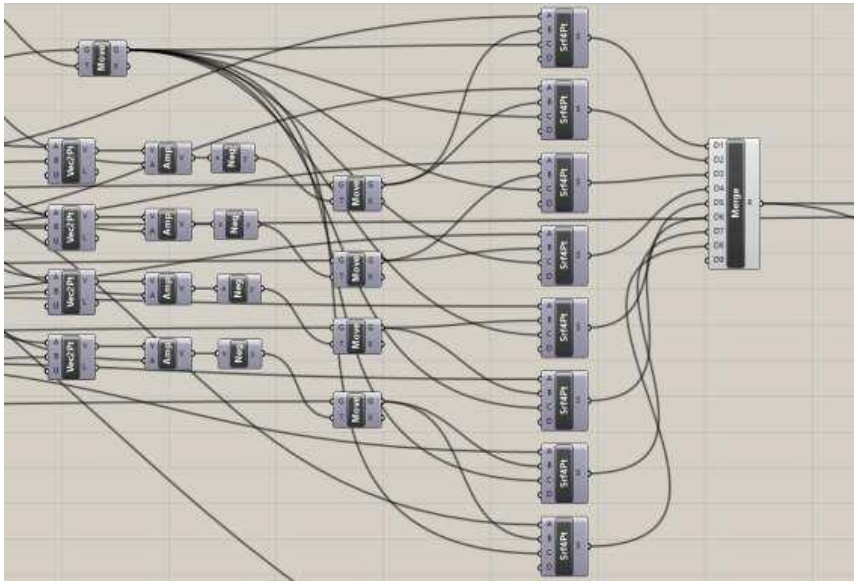


Methodology
Architectural analysis

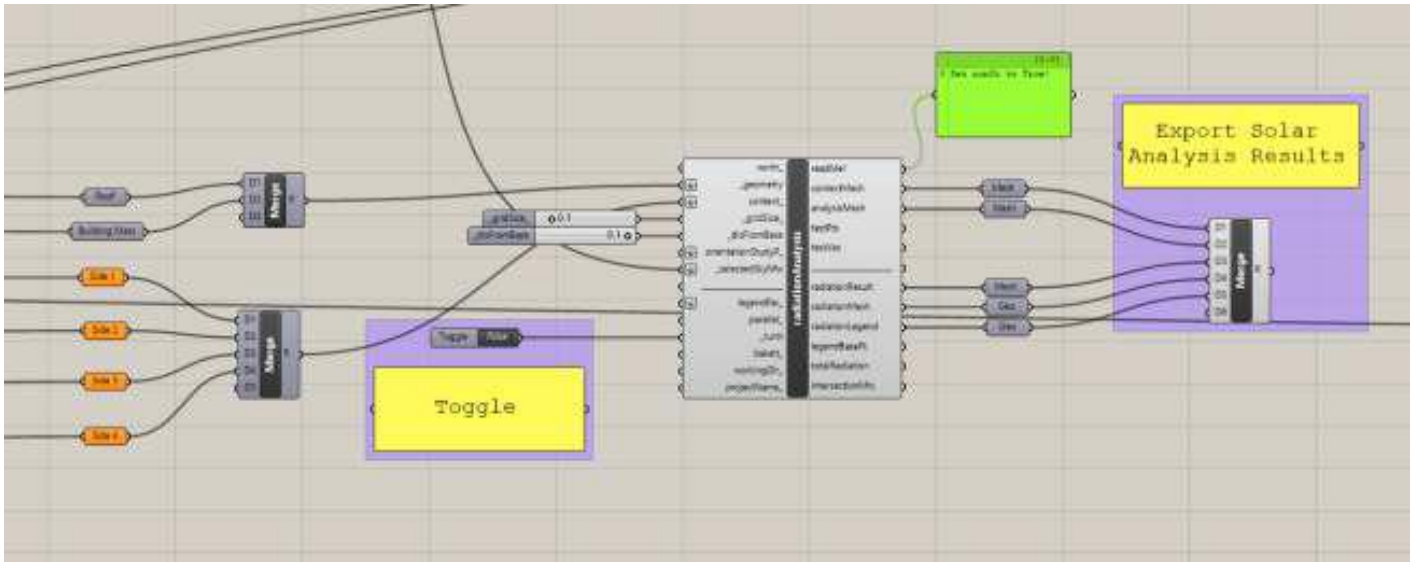




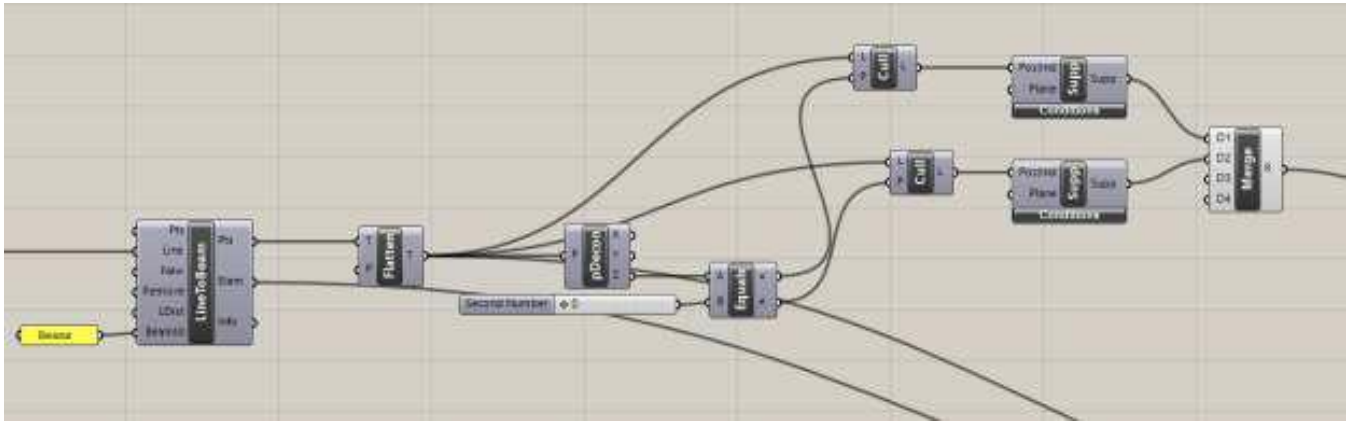
Cells Mechanism



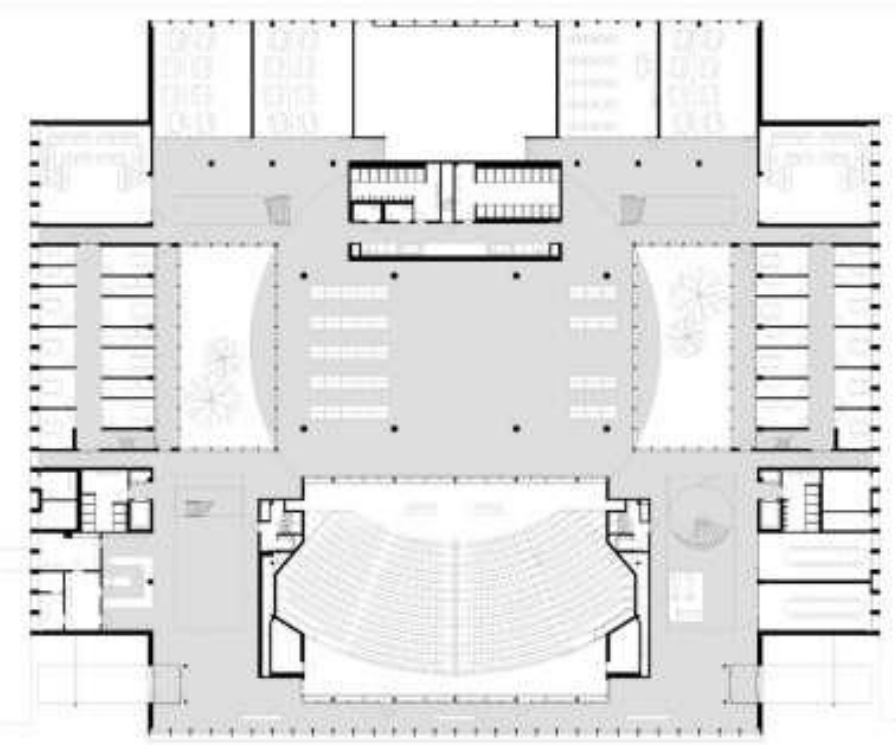
Simulation of cells of the kinetic shell façade (Grasshopper file)



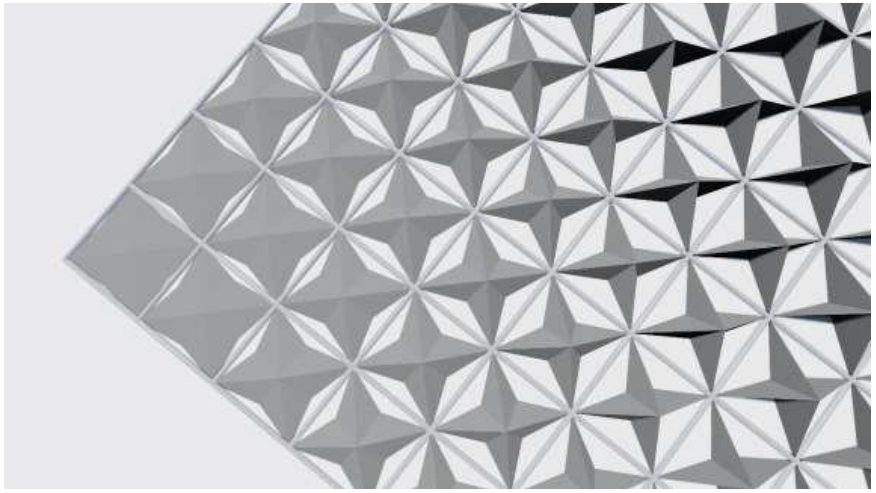
Simulation of Solar Analysis (Grasshopper file)



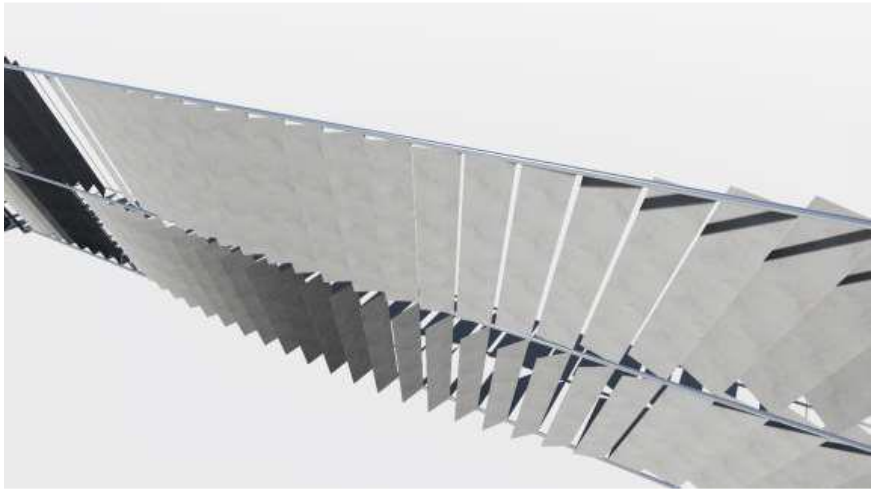
Structural Support (Grasshopper file)



Cube, Tilburg, Netherlands, Floor Plan.
Courtesy of http://kaanarchitecten.com, 2018



Option 1, Cells Render



Option 2, Vertical Panels Render

Building Model	Date	Time	Amount of radiation (kWh/m^2)	Time	Amount of radiation (kWh/m^2)
		CUBE building		Vaughan Civic Centre	
Original Mass Option	31st Dec.	10:00-11:00 11:00-12:00 12:00-13:00	46.266344 46.4565 191.440829	08:00-09:00 11:00-12:00 14:00-15:00	123.280769 98.978298 80.27975
	21st June	10:00-11:00 11:00-12:00 12:00-13:00	277.007711 299.808008 307.093605	08:00-09:00 11:00-12:00 14:00-15:00	389.43389 287.712422 271.900825
Option 1	31st Dec.	10:00-11:00 11:00-12:00 12:00-13:00	35.878934 57.429033 112.646116	08:00-09:00 11:00-12:00 14:00-15:00	36.701323 47.130328 39.128479
	21st June	10:00-11:00 11:00-12:00 12:00-13:00	219.433151 236.437601 241.654189	08:00-09:00 11:00-12:00 14:00-15:00	222.656853 157.438307 158.284735
Option 2	31st Dec.	10:00-11:00 11:00-12:00 12:00-13:00	31.509894 50.503567 99.228155	08:00-09:00 11:00-12:00 14:00-15:00	25.243718 41.921875 29.989777
	21st June	10:00-11:00 11:00-12:00 12:00-13:00	197.213665 210.014963 212.283023	08:00-09:00 11:00-12:00 14:00-15:00	149.671351 144.079064 137.323117

Conclusions

- Traditional design stages could be changed due to the emergence of adaptive design workflows and algorithms that enable data communication among various design tools/teams quickly and effectively
- By leveraging this design approach, it becomes possible for designers to generate more effective solutions.
- The developed BIM-Based parametric design workflow model of kinetic shell facades can help in the analysis of the façade performance to reduce the solar radiation on different times during the day.
- Further development can improve the model functions by providing more flexible design for any building shape or choice of materials and structure.
- Further development can utilise AI techniques to analyse/refine more optimum design solutions.