ARTIFICIAL REEF COST ANALYSIS

Preliminary study of the environmental and economic cost for the development of ”Macroalgae reefs” in the Limfjorden.

Juan Canal Vergés

28-11-2014

Table of Contents

Concrete Cost

Material	Emission factor	Unit
Coarse agg.- Granite	0,0459	KgCO2-eq / Kg
Coarse agg.- Basalt	0,0357	KgCO2-eq / Kg
Fine agg.- From raw sand	0,0139	KgCO2-eq / Kg
Cement	0,8200	KgCO2-eq / Kg
Fly ash	0,0270	KgCO2-eq / Kg
Natural Pozzolans	0,2560	KgCO2-eq / Kg
Ground granulated blast furnace slag	0,1430	KgCO2-eq / Kg
Concrete batching	3,3	KgCO2-eq / m3
Concrete transport	9,4	KgCO2-eq / m3
On site placement activities	9,0	KgCO2-eq / m3

Production Cost

Mix	Kg CO2-eq		
	Optimistic	Pessimistic	Average
JCV-1	5,48E+08	8,33E+08	6,91E+05
JCV-2	4,99E+08	7,58E+08	6,29E+05
JCV-3	3,87E+08	5,88E+08	4,88E+05

Density [Kg/m3]	JCV-1	2298,00
Density [Kg/m3]	JCV-2	2265,00
Density [Kg/m3]	JCV-3	1920,00

Total Cost

Mix	Kg CO2-eq		
	Optimistic	Pessimistic	Average
JCV-1	6,11E+08	9,30E+08	8,09E+07
JCV-2	5,62E+08	8,55E+08	8,08E+07
JCV-3	4,50E+08	6,85E+08	8,07E+07
Route	2	Medium	

Cost Summary

Mix	KgCO2-eq / m3 of concrete
JCV-1	480,886
JCV-2	431,441
JCV-3	283,688

Flower DJM, Sanjayan JG (2007): Green House Gas Emissions due to Concrete Manufacture. Int J LCA 12 (5) 282–288

Cost by Composition

JCV-1

Material	Weigh [Kg]	KgCO2-eq / m3 of concrete
Cement	495,00	405,90000
Fly Ash	55,00	1,48500
Natural Pozzolans	0,00	0,00000
Liapor 7	945,50	43,39845
Natural Sand	604,50	8,40255
Concrete batching		3,30000
Concrete transport		9,40000
On site placement activities		9,00000
Total		**480,88600**

JCV-2

Material	Weigh [Kg]	KgCO2-eq / m3 of concrete
Cement	385,00	315,70000
Fly Ash	0,00	0,00000
Natural Pozzolans	165,00	42,24000
Liapor 7	945,50	43,39845
Natural Sand	604,50	8,40255
Concrete batching		3,30000
Concrete transport		9,40000
On site placement activities		9,00000
Total		**431,441**

JCV-3

Material	Weigh [Kg]	KgCO2-eq / m3 of concrete
Cement	200,00	164,00000
Fly Ash	0,00	0,00000
Natural Pozzolans	200,00	51,20000
Liapor 7	854,00	39,19860
Natural Sand	546,00	7,58940
Concrete batching		3,30000
Concrete transport		9,40000
On site placement activities		9,00000
Total		**283,688**

Transport Cost

Impact Category (per ton)	Lorry, road	Freight Rail	Transoceanic freight Ship	Transport Impact/ton	Total Transport Impact
Primary energy demand [MJ-eq/Km]	3,266	0,751	0,170	452,260 [MJ-eq]	1,49E+09 [MJ-eq]
Global Warming Potential [KgCO2-eq/Km]	0,193	0,039	0,011	24,305 [KgCO2-eq]	8,02E+07 [KgCO2-eq]
Water demand[L/Km]	1,466	1,115	0,097	553,060 [L]	1,82E+09 [L]
Distance done	35,000	450,000	0,000	Copenhague-Skive(R);Skive-Nykøbing(L)	
Route 1	391,000	0,000	0,000	Copenhague-Nykøbing(L)	
Route 2	35,000	450,000	0,000	Copenhague-Skive(R);Skive-Nykøbing(L)	
Route 3	0,000	0,000	350,000	Copenhague-Nykøbing(S)	
Route 4	130,000	0,000	0,000	Aarhus, Aalborg, Hansholm… -Nykøbing(L)	
Route 5	30,000	0,000	0,000	*In situ*	

Material transported [tonnes]	Optimistic	Pessimistic	Average
	2,62E+06	3,98E+06	3,30E+06
Density of concrete [Kg/m3]	2200		
Route	2	Medium	

Transport Impact/m3
994,972 [MJ-eq]
53,471 [KgCO2-eq]
1216,732 [L]

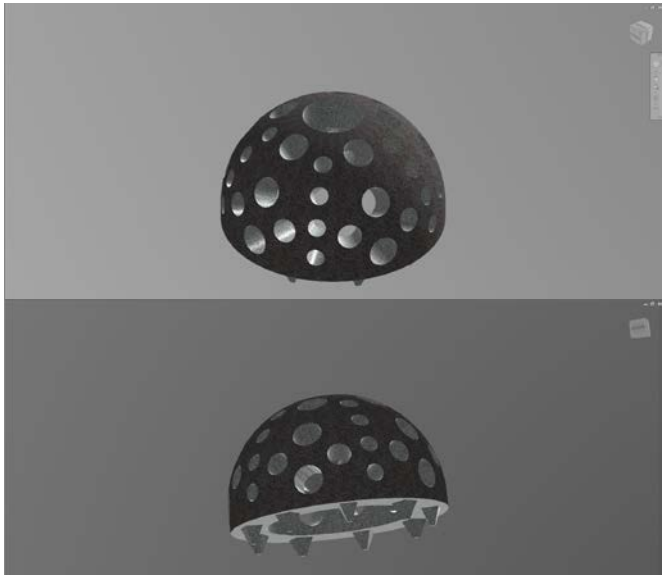
Total Transport Impact		
Optimistic	Pessimistic	Average
1,18E+09 [MJ-eq]	1,80E+09 [MJ-eq]	1,49E+09 [MJ-eq]
6,36E+07 [KgCO2-eq]	9,68E+07 [KgCO2-eq]	8,02E+07 [KgCO2-eq]
1,45E+09 [L]	2,20E+09 [L]	1,82E+09 [L]

Transportation Cost Concrete	
Route	**Global Warming Potential [KgCO2-eq]**
Route 1	2,49E+08
Route 2	8,02E+07
Route 3	1,27E+07
Route 4	8,28E+07
Route 5	1,91E+07

Concrete Needed

ReefBall Type Structure	
Height (m)	1,520
Diameter (m)	1,830
Unit Area (m2)	2,630
Aproximate Unit Area* (m2)	4,000
Useful Surface (m2)	21,400
Concrete Volume (m3)	1,190
Concrete density (kg/m3)	**2200,000**
Weight (Kg)	2618,000

*It is considered some distance between the structures



Volume of Concrete

Project Aim		Reef Area (m2)	2000000,00
		Number of Reef	2,00
		Total Area Requirement (m2)	4000000,00
ReefBall Type Solution	**Optimistic**	Aproximate Unit Area* (m2)	4,00
		Number of ReefBalls	1000000,00
		Area Provided (m2)	4000000,00
		Total Useful Surface (m2)	21400000,00
		Total Volume of Concrete (m3)	1190000,00
		Total Weight of Concrete (Kg)	2618000000,00
	Pessimistic	Unit Area (m2)	2,63
		Number of ReefBalls	1520786,00
		Approximate Area Provided* (m2)	6083144,00
		Total Useful Surface (m2)	32544820,40
		Total Volume of Concrete (m3)	1809735,34
		Total Weight of Concrete (Kg)	3981417748,00

*It is considered some distance between the structures

Total Weight Average [Kg]	**3,30E+09**

Economic Concrete Cost

Concrete price [DKK/m3]	kr. 1.525,00
Environmental taxes [DKK/m3]	kr. 25,00
Coarse agg. taxes [DKK/m3]	kr. 68,00
Indirect Cost	25%
Cost of concrete [DKK/m3]	**kr. 2.022,50**

	Optimistic	Pessimistic
Number of Reef Structures	1000000	1520786
Total molds [unit]	500	500
Reef Production [unit/day, mold]	1	1
Production time [years]*	8,00	12,17
Mold unit price [DKK/unit]	kr. 59.435,36	kr. 118.870,73

*Considering 250 workable days per year

	Optimistic	Pessimistic
Total Concrete [m3]	1190000,00	1809735,34
Cost of concrete [DKK/m3]	kr. 2.022,50	kr. 2.022,50
Total Cost of Concrete [DKK]	**kr. 2.406.775.000,00**	**kr. 3.660.189.725,15**
Total molds [unit]	500	500
Mold unit price [DKK/unit]	kr. 59.435,36	kr. 118.870,73
Total Cost of Molds [DKK]	**kr. 29.717.680,00**	**kr. 59.435.365,00**

Total Cost [DKK] , [€]	**kr. 2.436.492.680,00**	**327.485.575,27 €**	**kr. 3.719.625.090,15**	**499.949.608,89 €**
Unit Cost [Dkk, € /Reef]	**kr. 2.436,49**	**327,49 €**	**kr. 2.445,86**	**328,74 €**

Economic Concrete Cost (Realistic)

Concrete price [DKK/m3]	kr. 1.525,00
Environmental taxes [DKK/m3]	kr. 25,00
Coarse agg. taxes [DKK/m3]	kr. 68,00
Indirect Cost	25%
Cost of concrete [DKK/m3]	**kr. 2.022,50**

ReefBall Type Structure	
Height (m)	1,520
Diameter (m)	1,830
Unit Area (m2)	2,630
Aproximate Unit Area* (m2)	4,000
Useful Surface (m2)	21,400
Concrete Volume (m3)	1,190

	Cheap version	Expensive version
Number of Reef Structures	6153	15631
Total molds [unit]	10	20
Reef Production [unit/day, mold]	1	1
Production time [years]*	2,46	3,13
Mold unit price [DKK/unit]**	kr. 118.870,73	kr. 118.870,73
Total Area (m2)	24.612,00	62.524,00
Total useful surface (m2)	131.674,20	334.503,40

*Considering 250 workable days per year // **Considering the most expensive mold possible

	Cheap version	Expensive version
Total Concrete [m3]	7323,26	18602,02
Cost of concrete [DKK/m3]	kr. 2.022,50	kr. 2.022,50
Total Cost of Concrete [DKK]	**kr. 14.811.292,70**	**kr. 37.622.585,40**
Total molds [unit]	10	20
Mold unit price [DKK/unit]**	kr. 118.870,73	kr. 118.870,73
Total Cost of Molds [DKK]	**kr. 1.188.707,30**	**kr. 2.377.414,60**

Total Cost [DKK] , [€]	**kr. 16.000.000,00**	**2.150.537,63 €**	**kr. 40.000.000,00**	**5.376.344,09 €**
Unit Cost [Dkk, € /Reef]	**kr. 2.600,36**	**349,51 €**	**kr. 2.559,02**	**343,95 €**

Quarrying Cost

*Natural Stone Council-Life Cycle Inventory (2008)	Quarrying [x/m3]	Quarrying [x/Kg]
Embodied Energy [MJ/m3 granite]	14125,87	5,52
Embodied Water [L/m3 granite]	13,81	0,01
Global Warming Potential [Kg CO2 eq./m3 granite]	494,41	0,19
Density of the granite studied by the NSC [Kg/m3]	2560,00	

Comparative			
Quarrying	**NSC**	**UK**	**Difference**
Kg CO2eq./m3 Granite	494,41	237,92	208%
Kg CO2eq./Kg Granite	0,19	0,0929	208%
Quarrying	**Optimistic**	**Pessimistic**	**Average**
Kg CO2eq./m3 Granite	237,92	494,41	366,16111
Kg CO2eq./Kg Granite	0,09	0,19	0,14301

*Embodied carbon [Kg CO2eq./m3] United Kingdom (2008) [Q+P]

Material	Cradle-to-gate [KgCO2eq./m3]	Cradle-to-gate [KgCO2eq./Kg]
Sandstone	160,00	0,064
Granite	237,92	0,0929
Density of sandstone [Kg/m3]		2500,00
Density of granite [Kg/m3]		2561,00

Quarrying Cost		
View	**Kg CO2-eq. (based on Kg)**	
Optimistic	1,11E+09	
Pessimistic	2,32E+09	
Average	1,72E+09	
Density of Granite [Kg/m3]		2560
Material Quarried* [Kg]		1,20E+10

*It is the minimal material quarried. It would, probably, need some more material

Transport Cost

Impact Category (per ton)	Lorry, road	Freight rail	Transoceanic freight ship	Transport Impact/ton	Total Transport Impact
Primary energy demand [MJ-eq/Km]	3,266	0,751	0,170	495,578 [MJ-eq]	5,95E+09 [MJ-eq]
Global Warming Potential [KgCO2-eq/Km]	0,193	0,039	0,011	29,629 [KgCO2-eq]	3,56E+08 [KgCO2-eq]
Water demand[L/Km]	1,466	1,115	0,097	229,898 [L]	2,76E+09 [L]
Distance done	133,000	0,000	360,000	Oslo-Larvick(L); Larvick-Nykøbing(S)	
Route 1	309,200	0,000	163,000	Oslo-Larvick(L); Larvick-Hitshalls(S); Hitshalls-Nykøbing(L)	
Route 2	133,000	0,000	360,000	Oslo-Larvick(L); Larvick-Nykøbing(S)	
Route 3	0,000	0,000	477,000	Oslo-Nykøbing(S)	

Material transported [tonnes]	1,20E+07
Density of granite [Kg/m3]	2560

Route	2	Medium

Transport Impact/m3
1268,680 [MJ-eq]
75,850 [KgCO2-eq]
588,539 [L]

***Life cycle assessment of building materials: Comparative analysis of energy and environmental impacts and evaluation of the eco-efficiency improvement potential (Ignacio Zabalza Bribián et al.) (2010)**

Transportation Cost	
Route	**Global Warming Potential [KgCO2-eq]**
Route 1	7,38E+08
Route 2	3,56E+08
Route 3	6,30E+07

Life Cycle Inventory of Granite Production

LCI data of the production of	50,00	m2 of granite tiles (materials per m3*)

Industrial Flows	Inputs	Quarrying
Energy	L.V. electricity [kWh]	63,0000
	Diesel [MJ]	1095,0000
	Propane [MJ]	0,0000
Water	Cooling water [Kg]	1415,0000
Ancillary materials	Explosives [Kg]	1,1800
	Steels [Kg]	2,2700
	Oil and grease [Kg]	0,6400
Granite-raw material	Granite-gross [Kg]	8450,0000

Industrial Flows	Outputs	Quarrying
Granite product	Granite-net [Kg]	102,0000
Granite wastes	Granite sandust [Kg]	3,3700
	Granite scrap [Kg]	64,4000
Wastewater	Evaporated [Kg]	28,3000
Solid wastes	Mix of elements [Kg]	0,0533

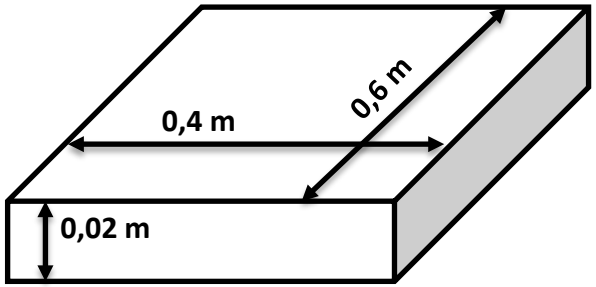
50 m2 of these granite tiles are equivalent to 1 m3 of granite*

4,167	Tile(s) Volume [m3]	
High	0,02	
Width	0,4	0,02
Depth	0,6	

208,3333	Tile(s) Volume [m3]	
High	0,02	
Width	0,4	1
Depth	0,6	

4,167	Tile(s) Surface [m2]	
Width	0,4	1
Depth	0,6	

208,3333	Tile(s) Surface [m2]	
Width	0,4	50,00
Depth	0,6	



***Life cycle inventory analysis of granite production from cradle to gate. (Joan-Manuel F. Mendoza et al.) (2013)**

Economic Granite Cost

	Cost by material	Proyect Budget
Material Needed [Kg]	1,20E+10	- -
Material Cost [DKK/Kg]*	kr. 1,34	- -

*Cost of 1998 by "LA INDUSTRIA DEL GRANITO. ANÁLISIS ECONÓMICO-CUANTITATIVA" (2000 UniOvi)

Total Cost [DKK] , [€]	**kr. 16.096.680.000,00**	**kr. 0,00**
	2.163.532.258,06 €	- €

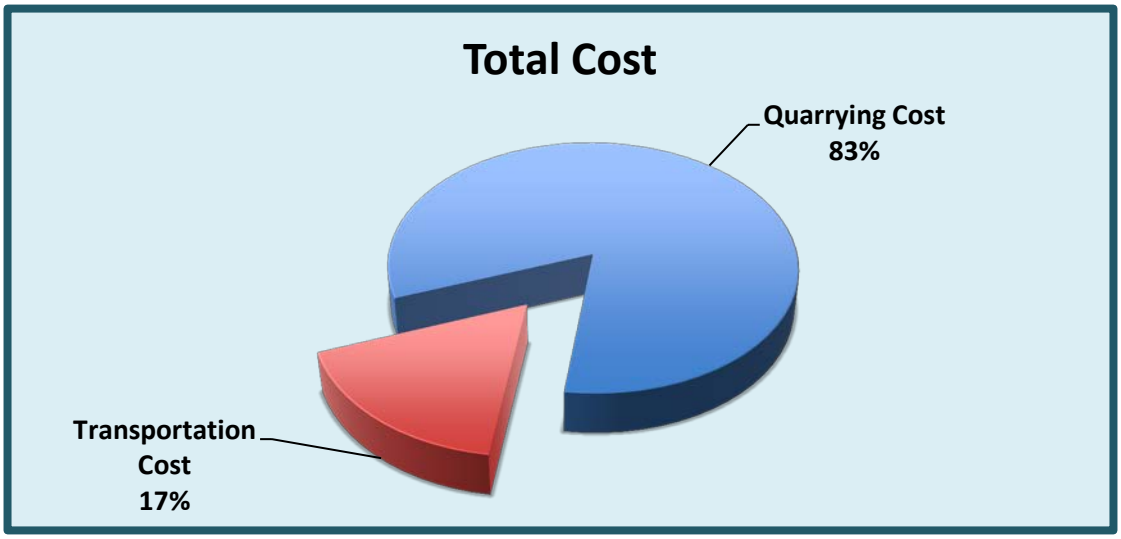
Granite (Quarry + Transportation)

Quarrying Cost	
View	**Kg CO2-eq. (based on Kg)**
Optimistic	1,11E+09
Pessimistic	2,32E+09
Average	1,72E+09
Density of Granite [Kg/m3]	2560
Material Quarried* [Kg]	1,20E+10

*It is the minimal material quarried. It would, probably, need some more material

Transportation Cost		
Impact Category		**Cost**
Primary energy demand [MJ-eq]		5,95E+09 [MJ-eq]
Global Warming Potential [KgCO2-eq]		3,56E+08 [KgCO2-eq]
Water demand[L]		2,76E+09 [L]
Route	2	**Medium**

Total Cost Average	**2,07E+09 [KgCO2-eq]**
Optimistic	1,47E+09 [KgCO2-eq]
Pessimistic	2,67E+09 [KgCO2-eq]

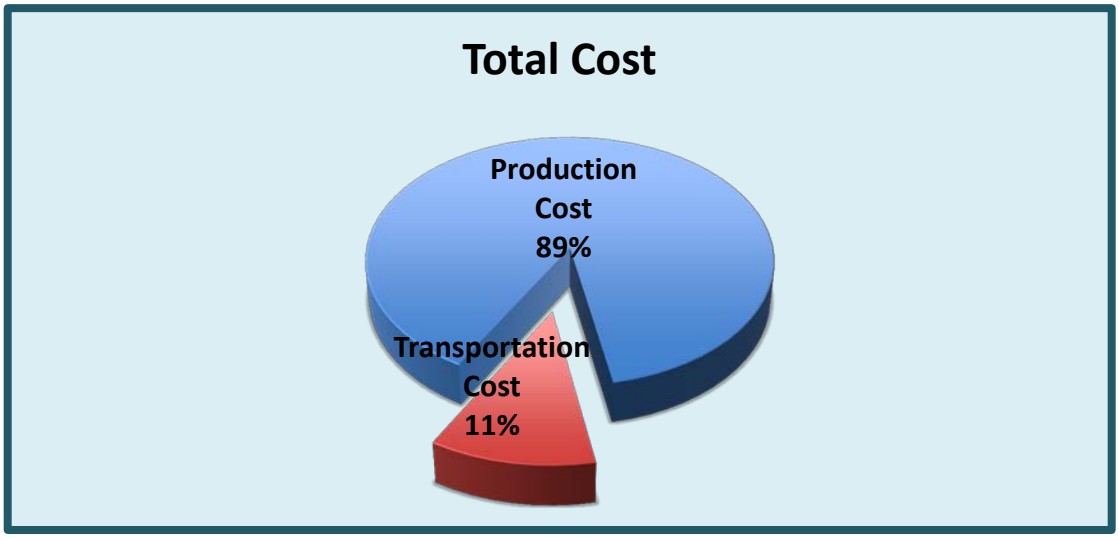


Concrete (Production + Transportation)

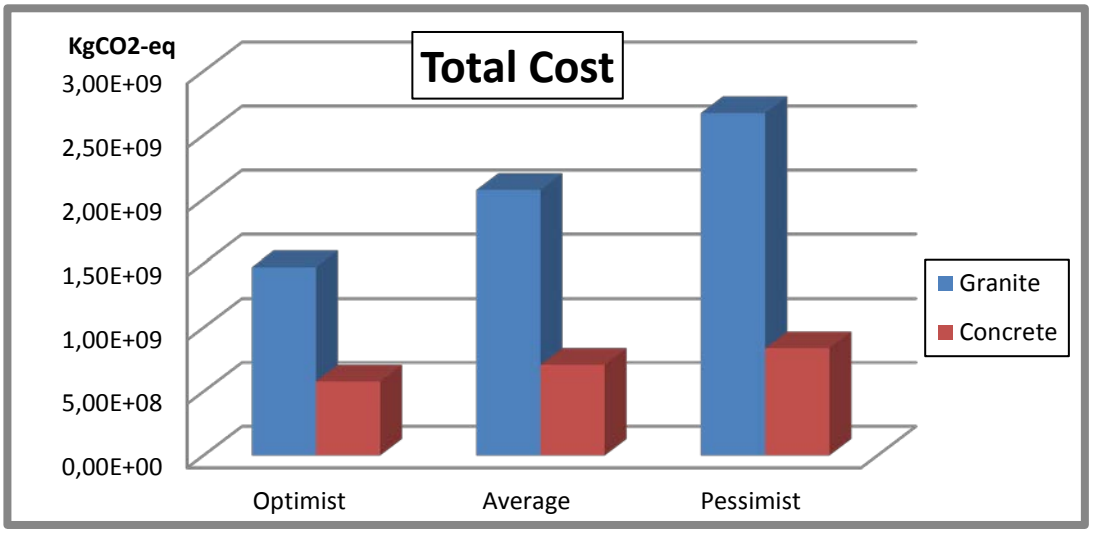
Production Cost			
Mix	Kg CO2-eq		
	JCV-1	JCV-2	JCV-3
Optimistic	5,48E+08	4,99E+08	3,87E+08
Pessimistic	8,33E+08	7,58E+08	5,88E+08
Average	6,91E+08	6,29E+08	4,88E+08
Density of concrete [Kg/m3] (Approx.)			2200
Total Weight of Concrete [Kg] (Average)			3,30E+09

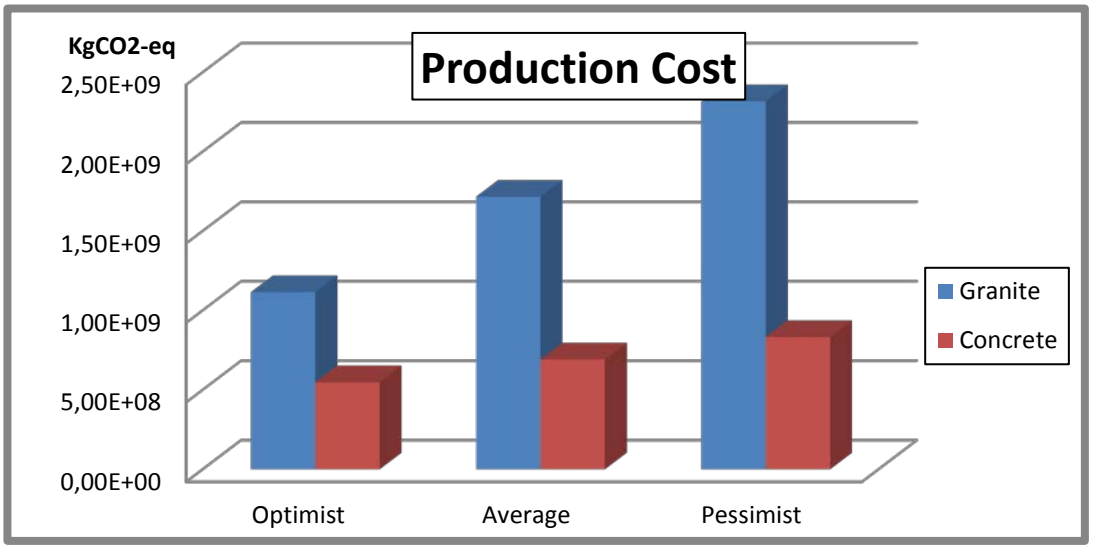
Transportation Cost		
Impact Category		Cost [Average]
Primary energy demand [MJ-eq]		1,49E+09 [MJ-eq]
Global Warming Potential [KgCO2-eq]		8,02E+07 [KgCO2-eq]
Water demand[L]		1,82E+09 [L]
Route	2	**Medium**

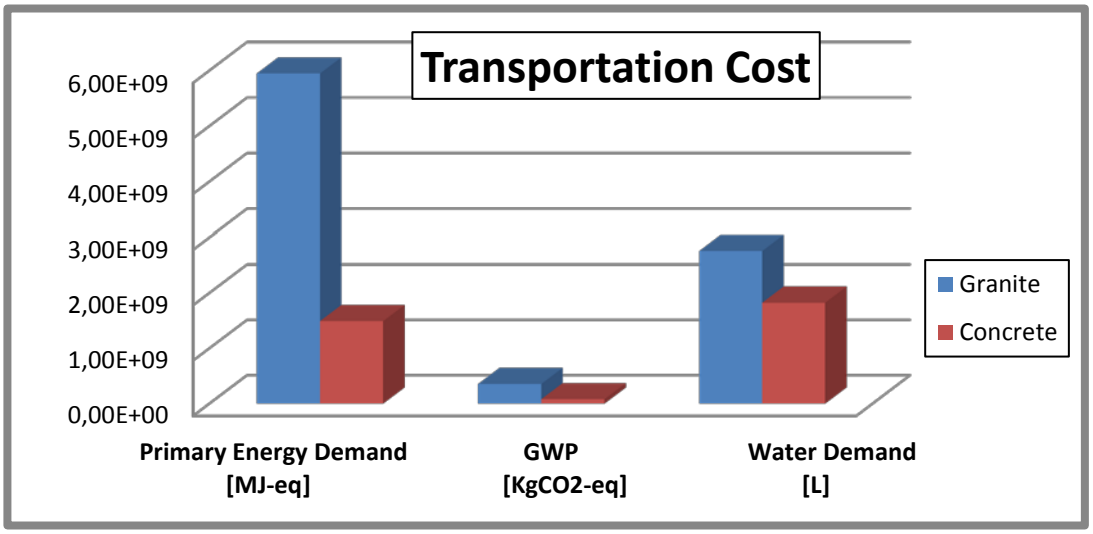
Total Cost Average		7,09E+08 [KgCO2-eq]
JCV-2	Optimistic	5,79E+08 [KgCO2-eq]
	Pessimistic	8,39E+08 [KgCO2-eq]



Comparative Granite vs Concrete



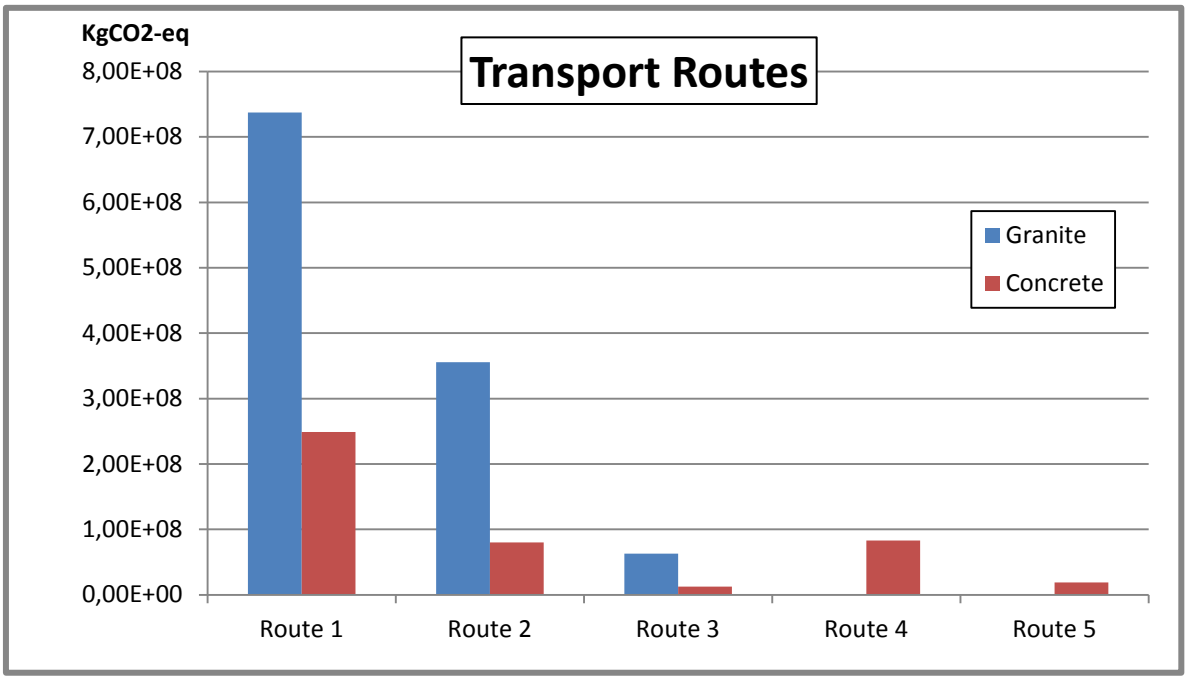




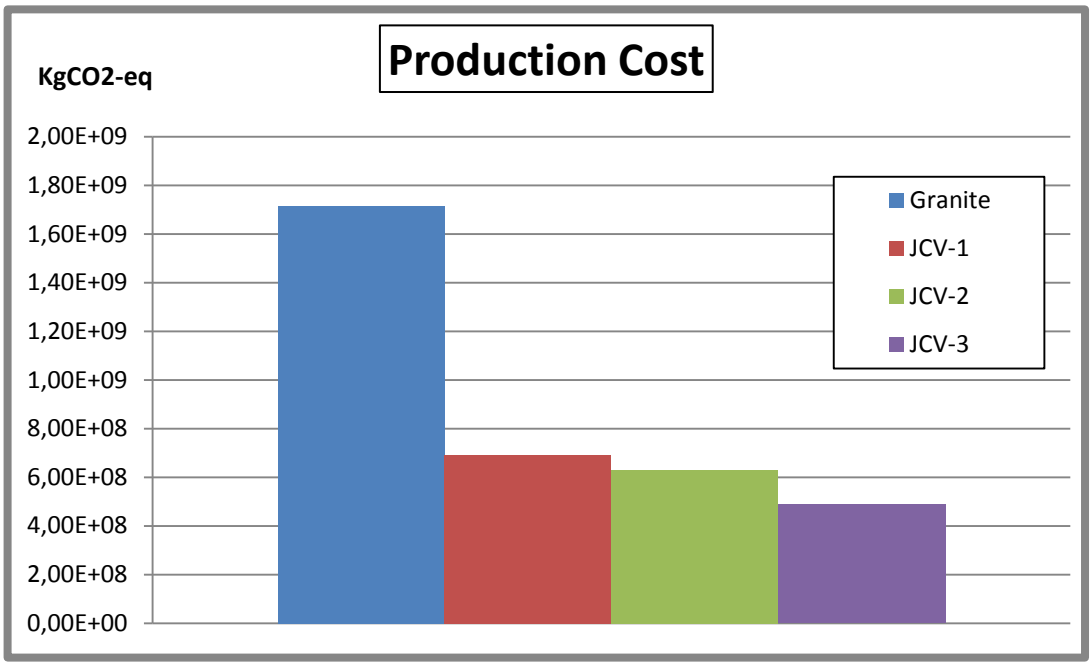
Comparative Transport

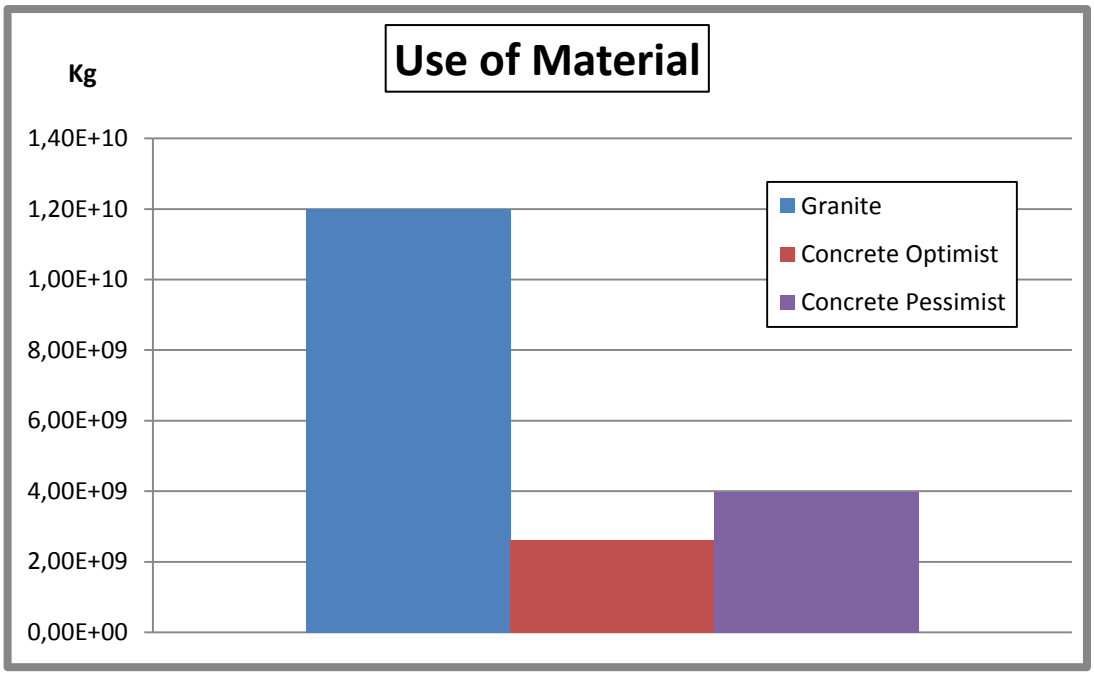
Transportation Cost Granite	
Route	**Global Warming Potential [KgCO2-eq]**
Route 1	7,38E+08
Route 2	3,56E+08
Route 3	6,30E+07

Transportation Cost Concrete	
Route	**Global Warming Potential [KgCO2-eq]**
Route 1	2,49E+08
Route 2	8,02E+07
Route 3	1,27E+07
Route 4	8,28E+07
Route 5	1,91E+07



Comparative Production





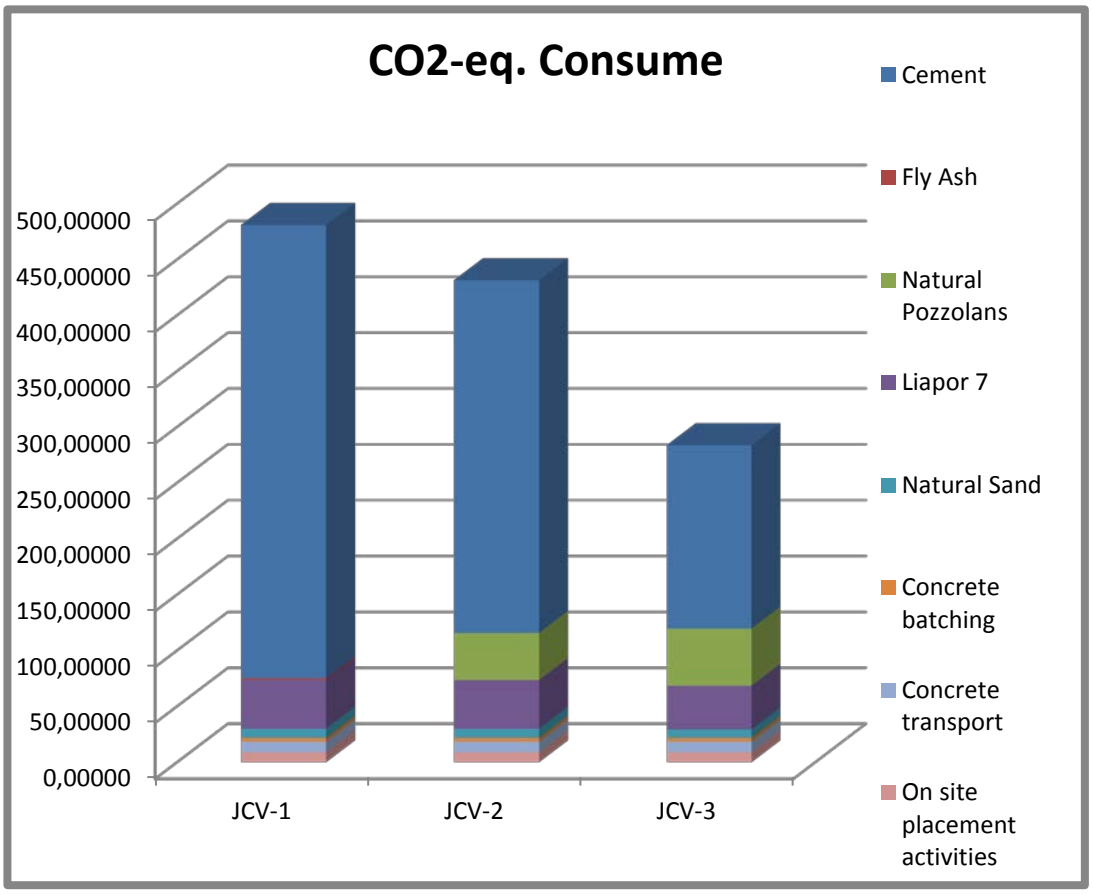
Cost by Composition Concrete (I)

JCV-1		
Material	Weigh [Kg]	KgCO2-eq / m3 of concrete
Cement	495,00	405,90000
Fly Ash	55,00	1,48500
Natural Pozzolans	0,00	0,00000
Liapor 7	945,50	43,39845
Natural Sand	604,50	8,40255
Concrete batching		3,30000
Concrete transport		9,40000
On site placement activities		9,00000
Total		**480,886**

JCV-2		
Material	Weigh [Kg]	KgCO2-eq / m3 of concrete
Cement	385,00	315,70000
Fly Ash	0,00	0,00000
Natural Pozzolans	165,00	42,24000
Liapor 7	945,50	43,39845
Natural Sand	604,50	8,40255
Concrete batching		3,30000
Concrete transport		9,40000
On site placement activities		9,00000
Total		**431,441**

JCV-3		
Material	Weigh [Kg]	KgCO2-eq / m3 of concrete
Cement	200,00	164,00000
Fly Ash	0,00	0,00000
Natural Pozzolans	200,00	51,20000
Liapor 7	854,00	39,19860
Natural Sand	546,00	7,58940
Concrete batching		3,30000
Concrete transport		9,40000
On site placement activities		9,00000
Total		**283,688**

Cost by Composition Concrete (II)



Summary Matrix

Global Warming Potential [KgCO2-eq]

		Granite	JCV-1	JCV-2	JCV-3
Pessimistic	Route 1	3,06E+09	1,08E+09	1,01E+09	8,37E+08
	Route 2	2,67E+09	9,13E+08	8,39E+08	6,68E+08
	Route 3	2,38E+09	8,46E+08	7,71E+08	6,01E+08
Average	Route 1	2,45E+09	9,40E+08	8,78E+08	7,37E+08
	Route 2	2,07E+09	7,71E+08	7,09E+08	5,68E+08
	Route 3	1,78E+09	7,03E+08	6,41E+08	5,00E+08
Optimistic	Route 1	1,85E+09	7,97E+08	7,48E+08	6,36E+08
	Route 2	1,47E+09	6,28E+08	5,79E+08	4,67E+08
	Route 3	1,18E+09	5,61E+08	5,11E+08	4,00E+08
Worst		3,06E+09	1,08E+09	1,01E+09	8,37E+08
Best		1,18E+09	5,61E+08	5,11E+08	4,00E+08

Economic Cost Comparative

Concrete

	Optimistic	Pessimistic
Total Concrete [m3]	1190000	1809735,34
Cost of concrete [DKK/m3]	2022,5	2022,5
Total Cost of Concrete [DKK]	**kr. 2.406.775.000,00**	**kr. 3.660.189.725,15**
Total molds [unit]	500	500
Mold unit price [DKK/unit]	59435,36	118870,73
Total Cost of Molds [DKK]	**kr. 29.717.680,00**	**kr. 59.435.365,00**

Total Cost [DKK] , [€]	**kr. 2.436.492.680,00**	**kr. 3.719.625.090,15**
	327.485.575,27 €	499.949.608,89 €

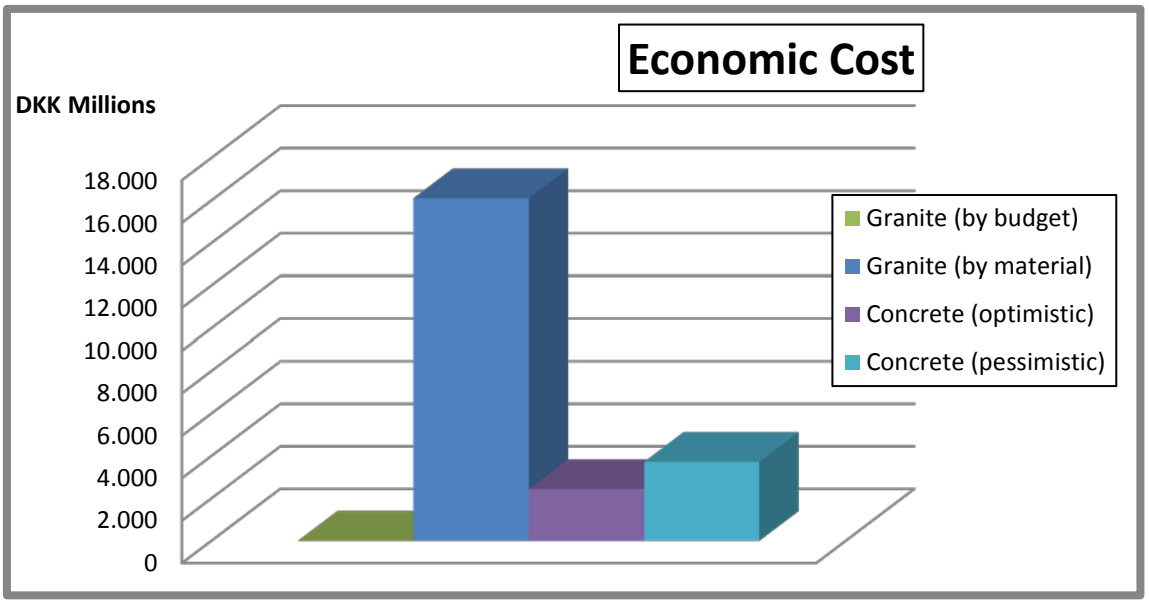
Unit Cost [Dkk, € /Reef]	**kr. 2.436,49**	**kr. 2.445,86**
	327,49 €	328,74 €

Granite

	Cost by material	Proyect Budget
Material Needed [Kg]	1,20E+10	- -
Material Cost [DKK/Kg]*	kr. 1,34	- -

*Price of 1998

Total Cost [DKK] , [€]	**kr. 16.096.680.000,00**	**kr. 0,00**
	2.163.532.258,06 €	- €



Realistic Project

Concrete

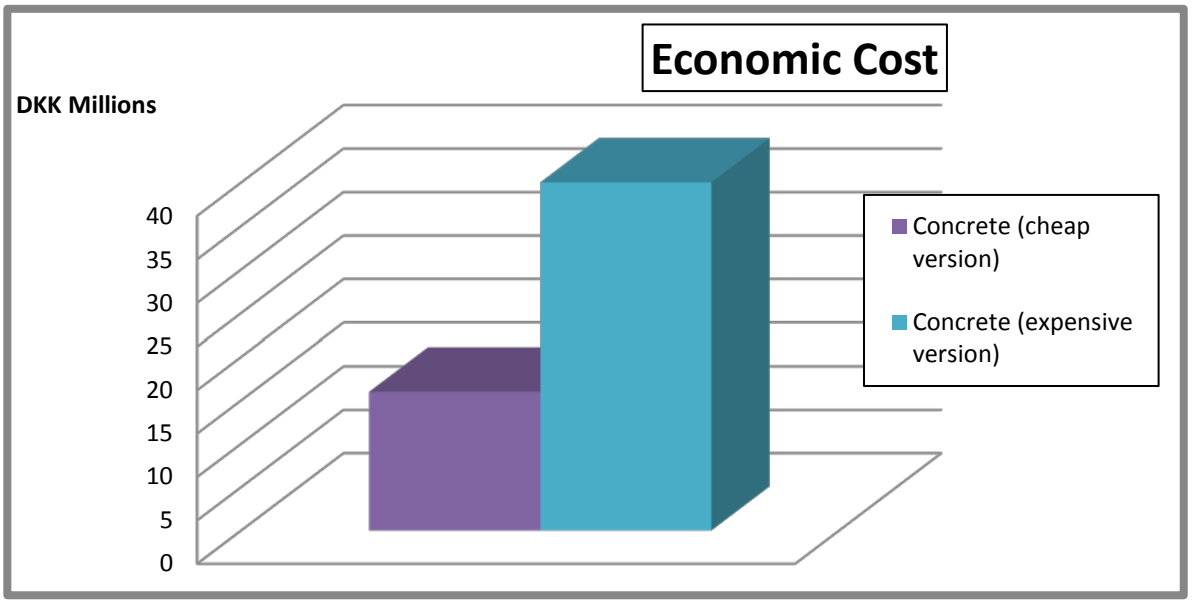
	Cheap version	Expensive version
Number of Reef Structures	6153	15631
Total molds [unit]	10	20
Reef Production [unit/day, mold]	1	1
Production time [years]*	2,46	3,13
Mold unit price [DKK/unit]**	kr. 118.870,73	kr. 118.870,73
Total Area (m2)	24.612,00	62.524,00
Total useful surface (m2)	131.674,20	334.503,40

*Considering 250 workable days per year // **Considering the most expensive mold possible

	Cheap version	Expensive version
Total Concrete [m3]	7323,26	18602,02
Cost of concrete [DKK/m3]	2022,50	2022,5
Total Cost of Concrete [DKK]	**kr. 14.811.292,70**	**kr. 37.622.585,40**
Total molds [unit]	10	20
Mold unit price [DKK/unit]	118870,73	118870,73
Total Cost of Molds [DKK]	**kr. 1.188.707,30**	**kr. 2.377.414,60**

Total Cost [DKK] , [€]	**kr. 16.000.000,00**	**kr. 40.000.000,00**
	2.150.537,63 €	5.376.344,09 €

Unit Cost [Dkk, € /Reef]	**kr. 2.600,36**	**kr. 2.559,02**
	349,51 €	343,95 €



Short Name	JCV-1
Denomination	SF/FA-MC_10/10-SAND_39-L7
Complete name	Silica Fume and Fly Ash (10%/10%) Mussel Cement (550Kg/m3) with 39% Sand replace of Liapor7

Cement Production

Material		Composition (%)		Considerations
Clinker			77%	Made with Mussel Shells
Natural Pozzolans	0%		0%	
Fly Ash	10%		10%	
Gypsum	3%		3%	
Silica Fume	10%		10%	
Others	0%		0%	

Concrete Production

Material		Composition (%)		Considerations
Water			8,62%	0,3 w/(c+SF+FA)
Cement			23,93%	Total concrete dry density 2100 [Kg/m3]
Aggregates			67,45%	with 39% sand replace of Liapor 7
Liapor 7	61%		41,14%	8 MSA [mm]
Natural Sand	39%		26,31%	

Hardening

Time	Strength	Density	Permeability	Surface	Moist	Color
3 days						
7 days						
14 days						
28 days						
60 days						
90 days						
180 days						

Short Name	JCV-2
Denomination	MPC-30_NP-SAND_39-L7
Complete name	Mussel Pozzolanic Cement with 30% of Natural Pozzolanas and 39% Sand replace of Liapor7

Cement Production

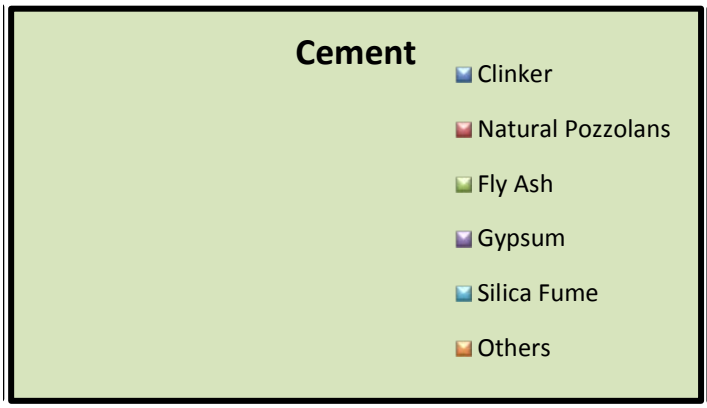
Material		Composition (%)		Considerations
Clinker			67%	Made with Mussel Shells
Natural Pozzolans	30%		30%	Basalt ash
Fly Ash	0%		0%	
Gypsum	3%		3%	
Silica Fume	0%		0%	
Others	0%		0%	

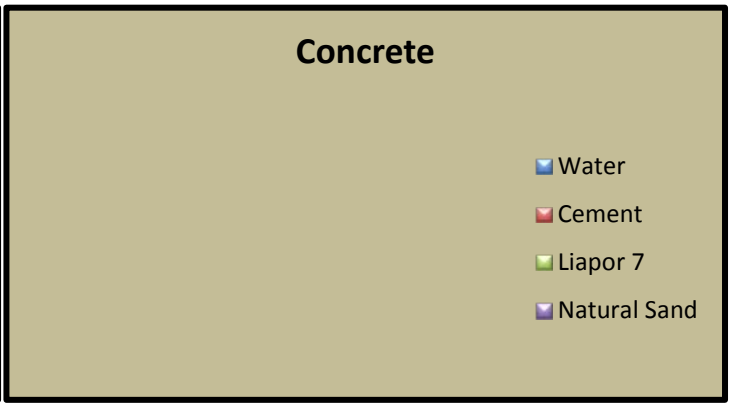
Concrete Production

Material		Composition (%)		Considerations
Water			7,28%	0,3 w/(c+SF+FA)
Cement			24,28%	Total concrete dry density 2100 [Kg/m3]
Aggregates			68,43%	with 39% sand replace of Liapor 7
Liapor 7	61%		41,74%	8 MSA [mm]
Natural Sand	39%		26,69%	

Hardening

Time	Strength	Density	Permeability	Surface	Moist	Color
3 days						
7 days						
14 days						
28 days						
60 days						
90 days						
180 days						





Short Name	JCV-3
Denomination	MPC-50_NP-SAND_39-L7
Complete name	Mussel Pozzolanic Cement with 50% of Natural Pozzolanas and 39% Sand replace of Liapor7

Cement Production

Material		Composition (%)		Considerations
Clinker			**47%**	Made with Mussel Shells
Natural Pozzolans	50%		**50%**	Basalt ash
Fly Ash	0%		**0%**	
Gypsum	3%		**3%**	
Silica Fume	0%		**0%**	
Others	0%		**0%**	

Concrete Production

Material		Composition (%)		Considerations
Water			**6,25%**	0,3 w/(c+SF+FA)
Cement			**20,83%**	Total concrete dry density 1800 [Kg/m3]
Aggregates			**72,92%**	with 39% sand replace of Liapor 7
Liapor 7	61%		**44,48%**	8 MSA [mm]
Natural Sand	39%		**28,44%**	

Hardening

Time	Strength	Density	Permeability	Surface	Moist	Color
3 days						
7 days						
14 days						
28 days						
60 days						
90 days						
180 days