

**PARAMETRIC DESIGN OF NON-CONVENTIONAL
DIAGRID SYSTEMS FOR TALL BUILDINGS**
PERFORMANCE OF STRUCTURAL GRIDS INSPIRED IN
HISTORICAL GEOMETRIC ISLAMIC ORNAMENTAL ART

APPENDIX I. DESIGN GUIDE

MATER THESIS
STRUCTURAL ENGINEERING // STRUCTURAL MECHANICS
TU DELFT // FACULTY OF CIVIL ENGINEERING (CiTG)

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In my thoughts are above all my parents, Eduardo Meri and Mari Carmen Celma, who relentless encouraged me to follow my dreams and achieve all my goals. And my brother Jose Luis who has always been my closest friend.

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THE PREDESIGN TOOL STEP BY STEP

This method can be applied indistinctively of the building shape, size and base material. Furthermore, this tool is very simple to implement in the sense that the pattern itself does not need to be drawn nor its bars to be modelled in order to have a rough idea of its performance, aesthetic view and amount of used material. At the same time, it gives enough freedom to the designer to change a variety of parameters to meet the drift limitations. The most straight-forward approach to apply the method is:

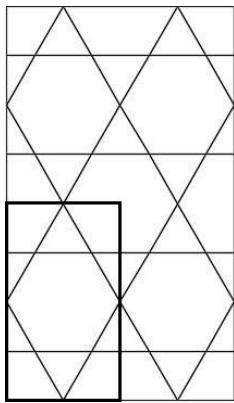
1. In *Chapter 3.3 Selection of historic geometric Islamic patterns*, there are displayed a series of historic geometric Islamic patterns and some parametric variations of them. The first step would be to **choose the desired pattern**. In order to make an informed choice, the designer should verify the suitability of the pattern in terms of structural performance with the help of the patterns performance comparison graphs included in *Chapter 5.2. Wire patterns performance* and *Chapter 5.4. Filled patterns performance*. The resulting information of this step is the definition of the generating tessellation, number of crossings, contact angle and filled or wire variation.
2. The number and size of modules is chosen for architectonic and structural purposes. For instance, if the pattern has regularly spaced horizontal lines it is convenient to make them coincide with the floor slabs. This step will **define the module size in the x-direction**. For instance, if the perimeter of the building façade measures 120m and 20 modules are chosen to cover horizontally that distance, each module will have a length in the x-direction of $120/20 = 6\text{m}$.
3. From the saturation tables introduced in *Chapter 3.5. Saturation and relative beam depth* and fully collected in *Appendix I. Design guide*, the designer will be able to visually **choose a desired saturation and its corresponding relative beam depth** that fits his needs such a determined opacity for solar gain, material minimization or overall aesthetic appearance. If the chosen relative beam depth is 5%, for the previous example the beam depth will be $6,5/100 = 0,3\text{m}$. It is suggested to choose a range of acceptable solutions instead of just one value to have a better insight on the possible solutions
4. **Obtain the homogenized mechanical properties** of an equivalent metamaterial, there are two alternatives:
 - a) For wire patterns (as they have appeared in this document so far, built up with assembled beams), use the ideal homogenized mechanical properties introduced in *Chapter 4.8. Ideal homogenized mechanical properties* and fully collected in *Appendix I. Design guide*.
 - b) For filled-stars patterns use the homogenized mechanical properties introduced in *Chapter 5.3. Stars filling*.
5. **Rotate the pattern to its desired orientation**. For historic Islamic geometric patterns with empty stars, it is done multiplying directly the mechanical properties times the rotation factors from *Chapter 5.1. Directional mechanical properties*. In case of the proposed variations and filled stars patterns, the designer has to calculate the rotation factor himself following the steps explained in that same chapter with the constitutive coefficients obtained from the tests and included in the *Appendix II. Numerical results*.
6. **Chose the structural base material**, being it high strength concrete, steel, a composite or any other material. The homogenized mechanical properties times the modulus of elasticity of the base are the mechanical properties of the equivalent continuous material (except for the Poisson ratio that is taken directly) that will be inputted in the orthotropic material crated in a FEM software.
7. **Model the building with a FEM software**, using continuous shear wall elements covering the whole façade. Apply the design loads and run the wind combination with a displacement limitation in the top floor.
8. Run the model iteratively so the program can get the **required wall thickness to meet the drift limitation**.
9. Saturation times the façade surface times the mean thickness, is an **estimation of the required use of material**

1. SATURATION TABLES

This chapter includes the following information regarding the historic Islamic patterns under study as well as two of their parametric variations for each case:

- **Module identification:** This picture allows the designer to easily identify what is the pattern module as its length in the x-direction is required to get the absolute beam depth from the relative beam depth in the tables.
- **Saturation table:** The saturation values are obtained varying the beams depth in Grasshopper and retrieving the saturation value. This table gives the corresponding saturation (Sat. %) for a given relative beam depth (rbd %).
- **Linearly interpolated saturation table;** To facilitate the comparison between patterns and in order to give more tools to the designer, the saturation table's values are linearly interpolated. This table gives the corresponding relative beam depth (rbd %) for a given saturation (Sat. %). Note that the values in this table are less accurate.
- **Extruded patterns:** Those pictures display how the pattern and saturation would look like for different relative beam depths. It is intended to help the designer visualize the resulting appearance in order to take informed decisions and limit the range of the desired relative beam depth (rbd) or saturation (Sat)

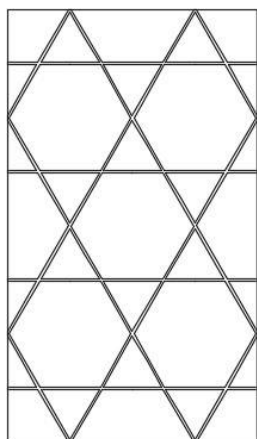
A) YESLI MOSQUE



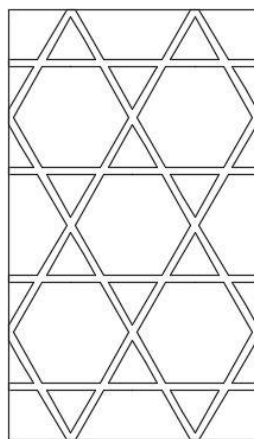
3.6.3.6. YESLI MOSQUE			
rbd %		$\theta = 0^\circ$	
2.0		6.11	
4.0		12.01	
6.0		17.70	
8.0		23.18	
10.0		28.46	
12.0		33.53	
14.0		38.39	
16.0		43.04	
18.0		47.49	

3.6.3.6. YESLI MOSQUE			
Sat. %		$\theta = 0^\circ$	
10		3.00	
15		4.58	
20		6.23	
25		7.95	
30		9.76	
35		11.68	
40		13.72	
45		15.91	
50		18.28	

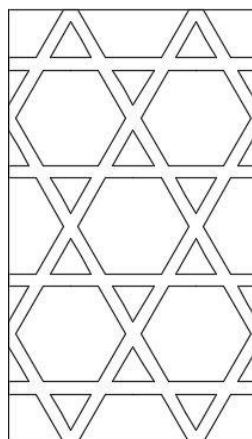
TABLE AP1.1.1. Saturation tables for tessellation 3.6.3.6.



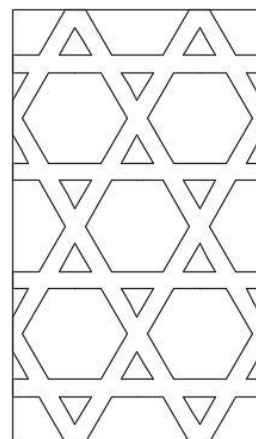
$\theta=0^\circ$ - rbd 2%



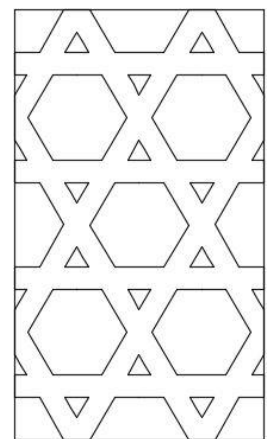
$\theta=0^\circ$ - rbd 6%



$\theta=0^\circ$ - rbd 10%



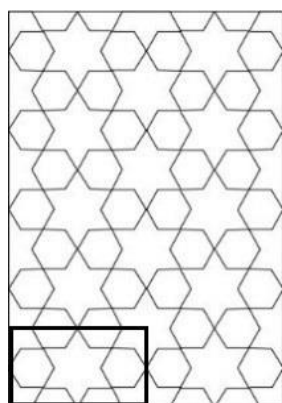
$\theta=0^\circ$ - rbd 14%



$\theta=0^\circ$ - rbd 18%

FIG AP1.1.1. Tessellation 3.6.3.6. different relative beam depths applied to the parametric variations

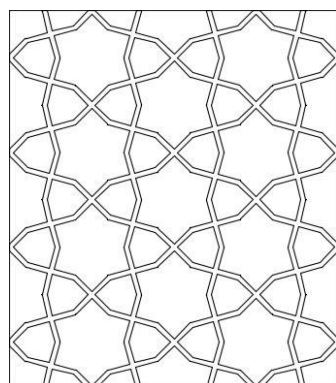
B) GREAT MOSQUE OF DAMASCUS



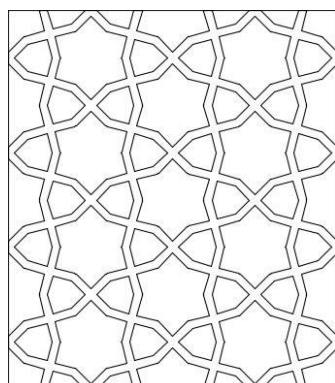
6.6.6 GREAT MOSQUE OF DAMASCUS			
rbd %	$\theta = 45^\circ$	$\theta = 60^\circ$	$\theta = 75^\circ$
1.0	6.11	6.81	8.28
2.0	12.01	13.38	16.14
3.0	17.70	19.70	23.59
4.0	23.18	25.80	30.62
5.0	28.46	31.64	37.23
6.0	33.53	37.25	43.43
7.0	38.39	42.62	49.21
8.0	43.04	47.75	54.58
9.0	47.49	52.63	59.53

6.6.6 GREAT MOSQUE OF DAMASCUS			
Sat. %	$\theta = 45^\circ$	$\theta = 60^\circ$	$\theta = 75^\circ$
10	1.66	1.49	1.22
15	2.53	2.26	1.86
20	3.42	3.05	2.52
25	4.34	3.87	3.20
30	5.30	4.72	3.91
35	6.30	5.60	4.66
40	7.35	6.51	5.45
45	8.44	7.46	6.27
50	9.59	8.46	7.15

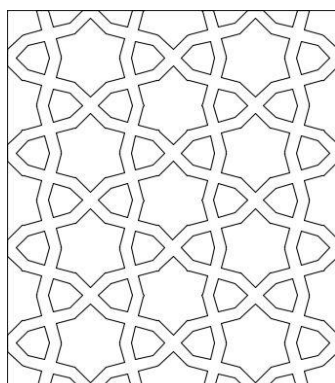
TABLE AP1.1.2. Saturation tables for tessellation 6.6.6.



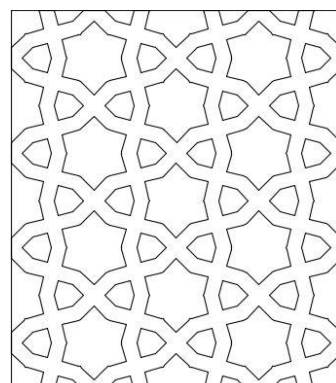
$\theta = 45^\circ$ - rbd 3%



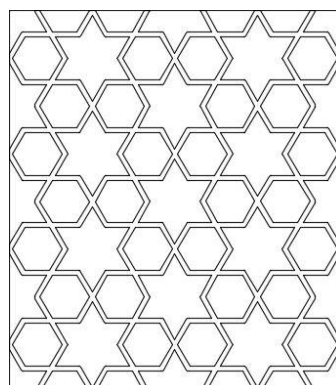
$\theta = 45^\circ$ - rbd 5%



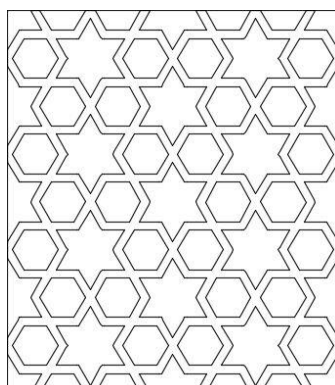
$\theta = 45^\circ$ - rbd 7%



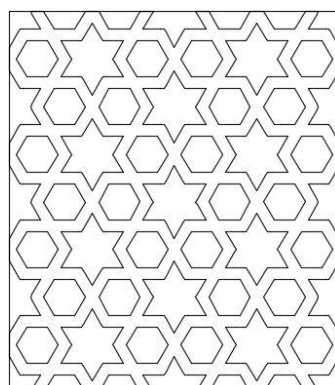
$\theta = 45^\circ$ - rbd 9%



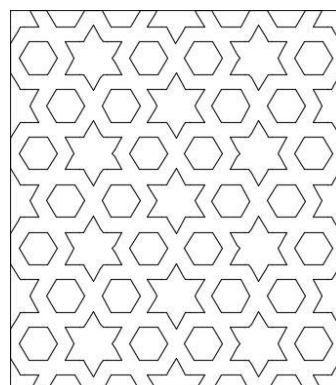
$\theta = 60^\circ$ - rbd 3%



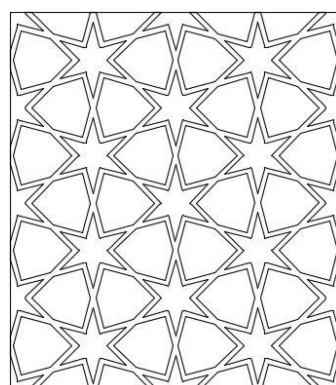
$\theta = 60^\circ$ - rbd 5%



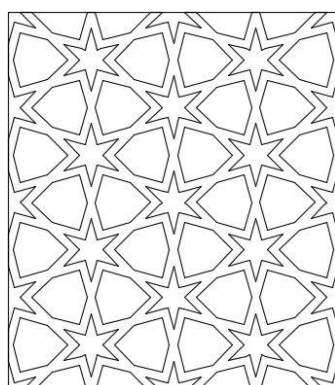
$\theta = 60^\circ$ - rbd 7%



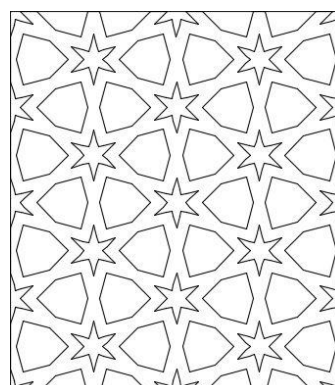
$\theta = 60^\circ$ - rbd 9%



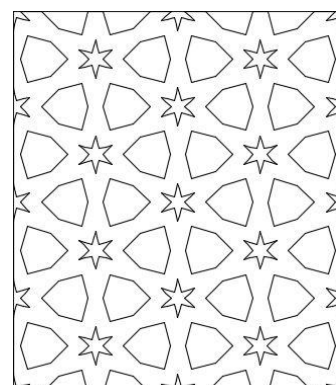
$\theta = 75^\circ$ - rbd 3%



$\theta = 75^\circ$ - rbd 5%



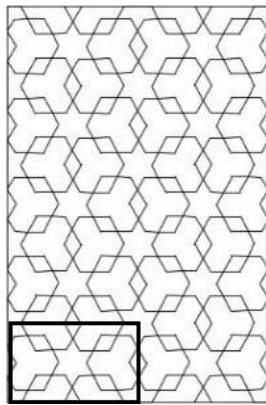
$\theta = 75^\circ$ - rbd 7%



$\theta = 75^\circ$ - rbd 9%

FIG AP1.1.2. Tessellation 6.6.6. different relative beam depths applied to the parametric variations

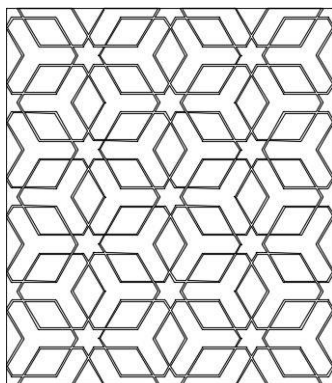
C) SABZ PUSHAN



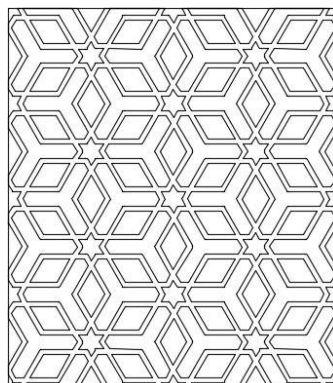
D6.6.6 SABZ PUSHAN			
rbd %	D = 20%	D = 35%	D = 50%
1.0	10.81	8.77	6.81
2.0	21.14	17.07	13.38
3.0	30.99	24.88	19.71
4.0	40.36	32.22	25.80
5.0	49.25	39.07	31.64
6.0	57.66	45.44	37.25
7.0	65.59	51.34	42.62
8.0	X	X	47.75
9.0	X	X	48.75

D6.6.6 SABZ PUSHAN			
Sat. %	D = 20%	D = 35%	D = 50%
10	0.92	1.15	1.49
15	1.41	1.75	2.26
20	1.89	2.38	3.05
25	2.39	3.02	3.87
30	2.90	3.70	4.72
35	3.43	4.41	5.60
40	3.96	5.15	6.51
45	4.52	5.93	7.46
50	5.09	6.77	8.46

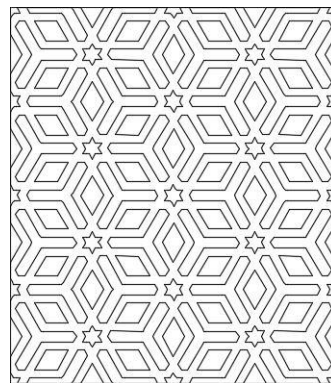
TABLE AP1.1.3. Saturation tables for tessellation 6.6.6 $\theta = 60^\circ$



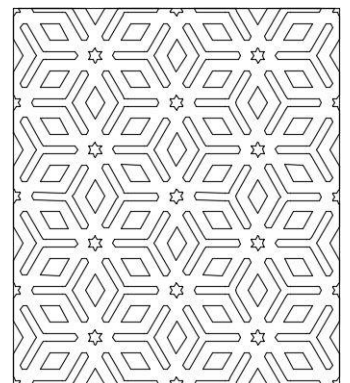
D = 20% - rbd 1%



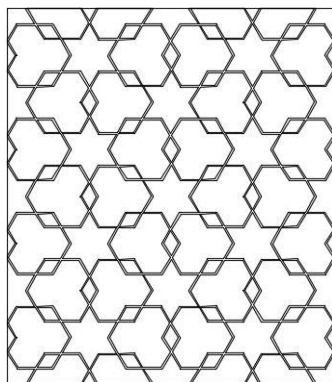
D = 20% - rbd 3%



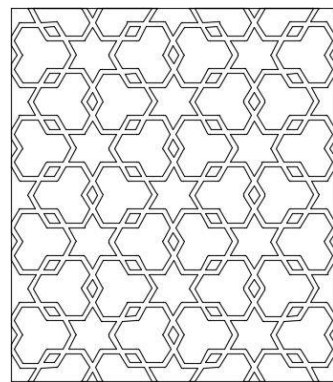
D = 20% - rbd 5%



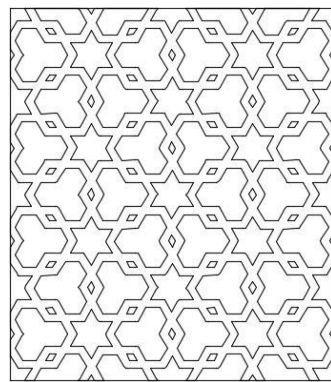
D = 20% - rbd 7%



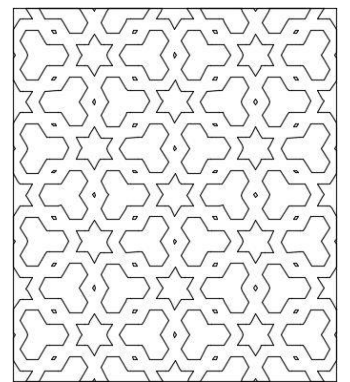
D = 35% - rbd 1%



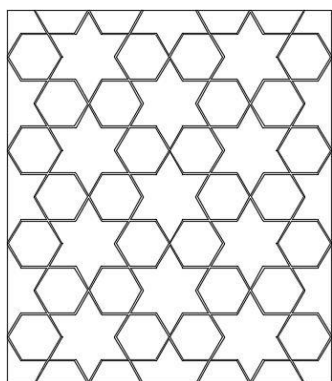
D = 35% - Rel. beam 3%



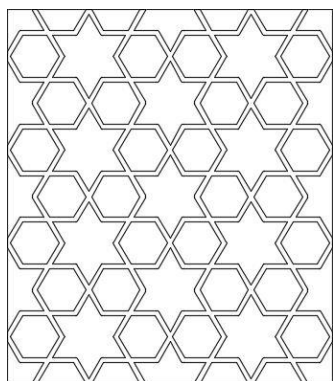
D = 35% - rbd 5%



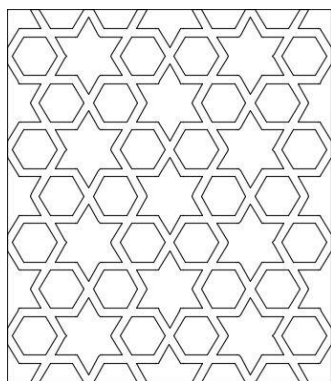
D = 35% - rbd 7%



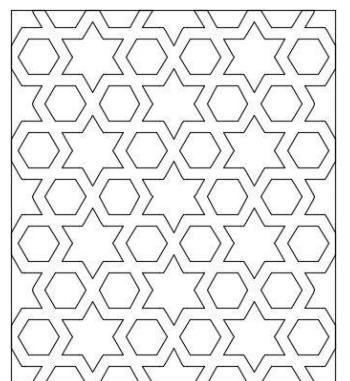
D = 50% - rbd 1%



D = 50% - rbd 3%



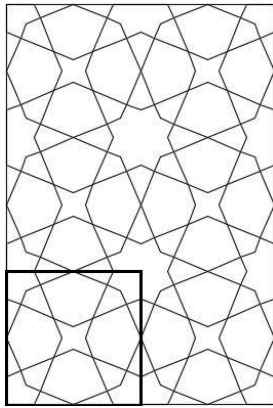
D = 50% - rbd 5%



D = 50% - rbd 7%

FIG AP1.1.3. Tessellation 6.6.6 $\theta = 60^\circ$ different relative beam depths applied to the parametric variations

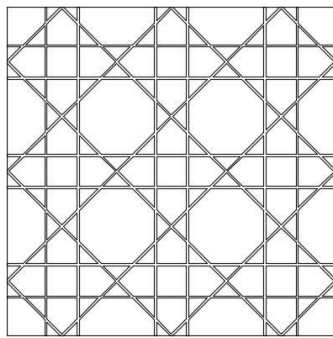
D) LAHORE FORT COMPLEX



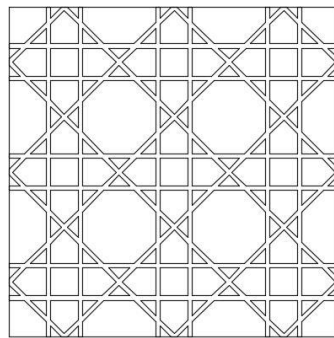
4.8.8 LAHORE FORT			
rbd %	$\theta = 45^\circ$	$\theta = 60^\circ$	$\theta = 67.5^\circ$
1.0	6.66	6.92	7.23
2.0	12.96	13.53	14.12
3.0	18.93	19.84	20.69
4.0	24.54	25.84	26.93
5.0	29.81	31.54	32.83
6.0	34.74	36.94	38.41
7.0	39.32	42.03	43.66
8.0	43.55	46.82	48.58
9.0	47.43	51.30	53.17

4.8.8 LAHORE FORT			
Sat. %	$\theta = 45^\circ$	$\theta = 60^\circ$	$\theta = 67.5^\circ$
10	1.53	1.47	1.40
15	2.34	2.23	2.13
20	3.19	3.03	2.90
25	4.09	3.86	3.69
30	5.04	4.73	4.52
35	6.06	5.64	5.39
40	7.16	6.60	6.30
45	8.37	7.62	7.27
50	9.66	8.71	8.31

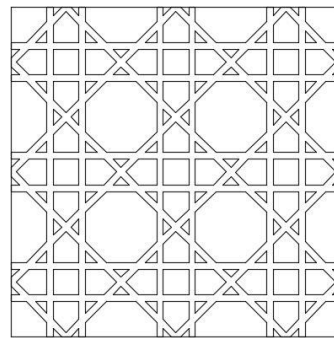
TABLE AP1.1.4. Saturation tables for tessellation 4.8.8.



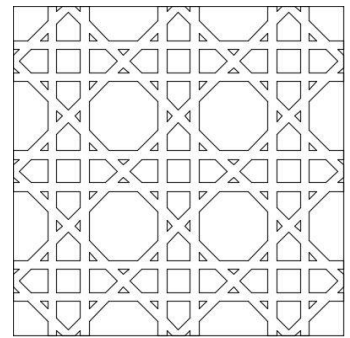
$\theta=45^\circ$ - rbd 2%



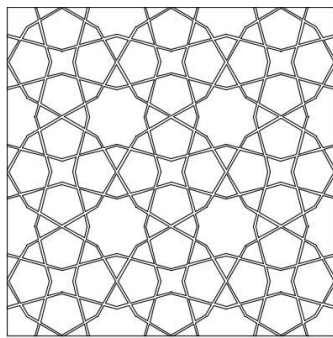
$\theta=45^\circ$ - rbd 4%



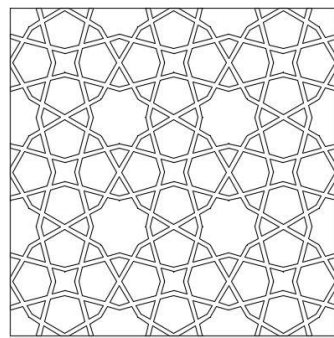
$\theta=45^\circ$ - rbd 6%



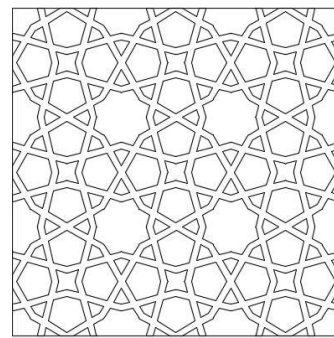
$\theta=45^\circ$ - rbd 8%



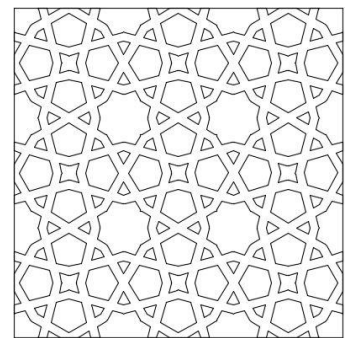
$\theta=60^\circ$ - rbd 2%



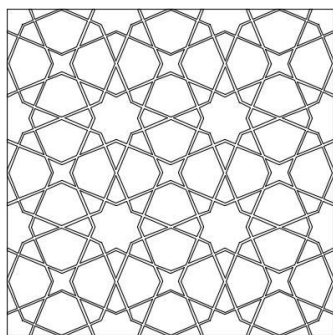
$\theta=60^\circ$ - rbd 4%



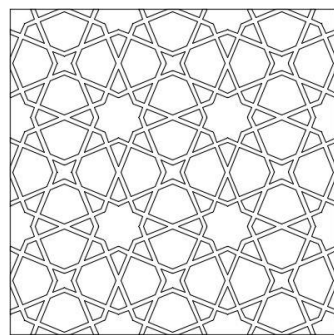
$\theta=60^\circ$ - Rel. beam 6%



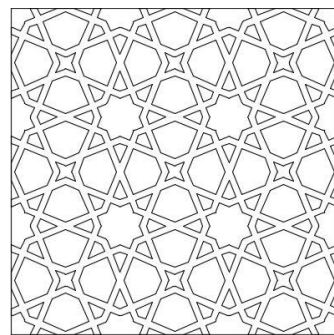
$\theta=60^\circ$ - rbd 8%



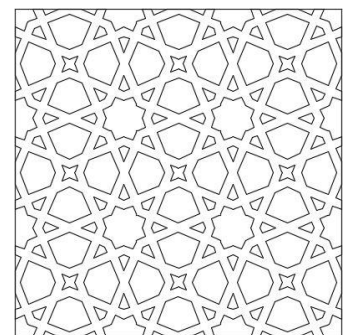
$\theta=67.5^\circ$ - rbd 2%



$\theta=67.5^\circ$ - rbd 4%



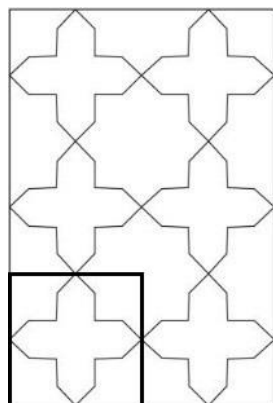
$\theta=67.5^\circ$ - rbd 6%



$\theta=67.5^\circ$ - rbd 8%

FIG AP1.1.4. Tessellation 4.8.8. different relative beam depths applied to the parametric variations

E) PALACE OF THE SHIRVANSHAHS



4.8.8 PALACE OF THE SHIRVANSHAHS			
rbd %	$\theta = 45^\circ$	$\theta = 60^\circ$	$\theta = 75^\circ$
1.0	4.93	5.75	7.53
2.0	9.76	11.44	15.03
3.0	14.51	17.05	22.50
4.0	19.16	22.60	29.95
5.0	23.73	28.08	37.36
6.0	28.21	33.49	44.66
7.0	32.60	38.83	51.52
8.0	36.89	44.10	57.91
9.0	41.10	49.30	63.84

4.8.8 PALACE OF THE SHIRVANSHAHS			
Sat. %	$\theta = 45^\circ$	$\theta = 60^\circ$	$\theta = 75^\circ$
10	2.05	1.75	1.33
15	3.11	2.63	2.00
20	4.18	3.53	2.67
25	5.28	4.44	3.34
30	6.41	5.36	4.01
35	7.56	6.28	4.68
40	8.74	7.22	5.36
45	9.95	8.17	6.05
50	11.19	9.14	6.78

TABLE AP1.1.5. Saturation tables for tessellation 4.8.8.

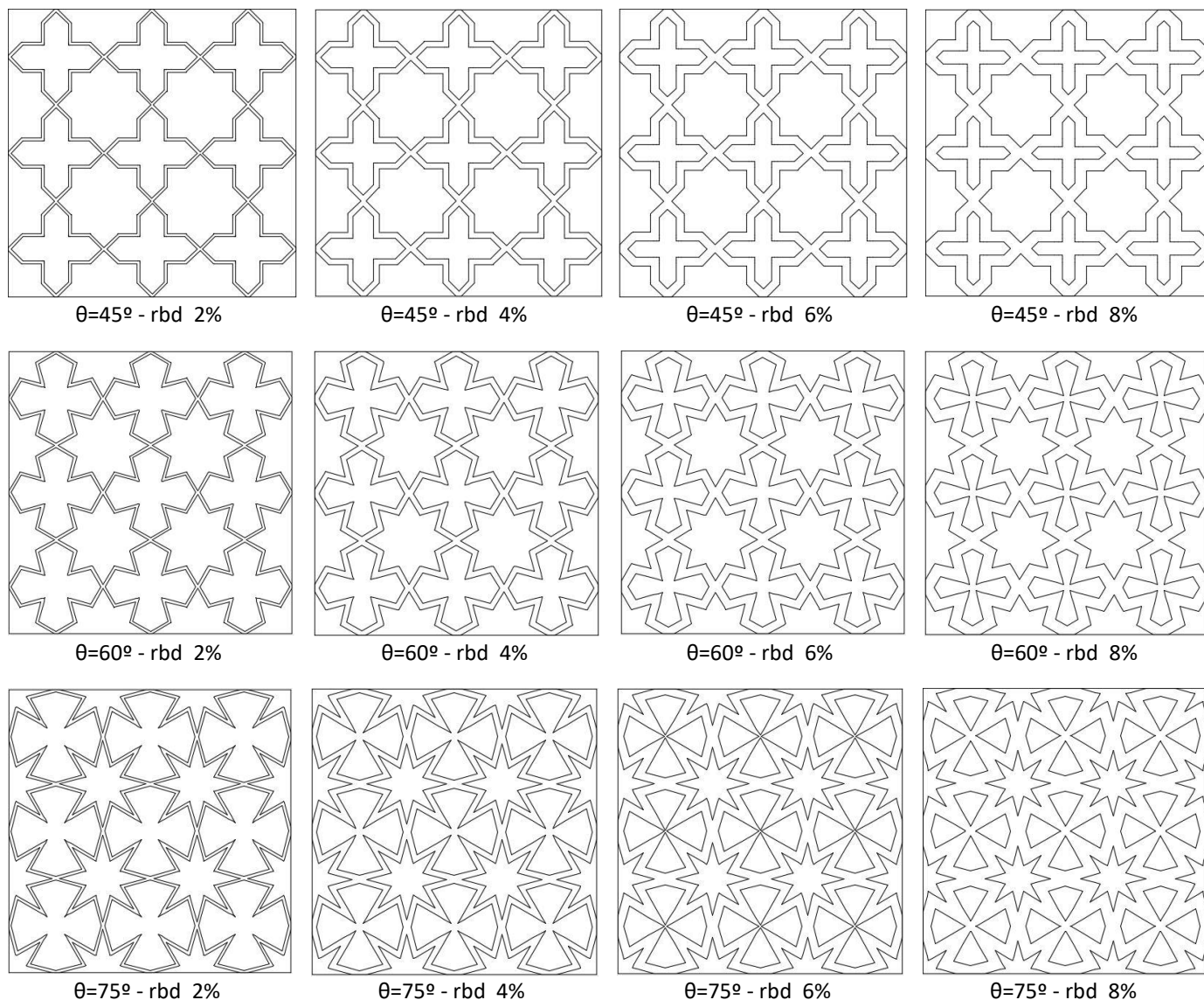
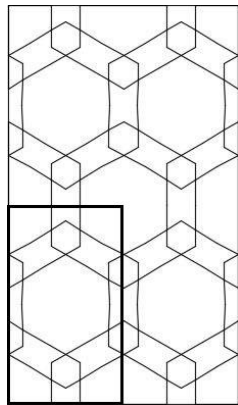


FIG AP1.1.5. Tessellation 4.8.8. different relative beam depths applied to the parametric variations

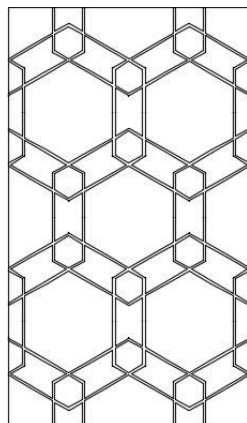
F) MUSTANSIRIYA MADRASA



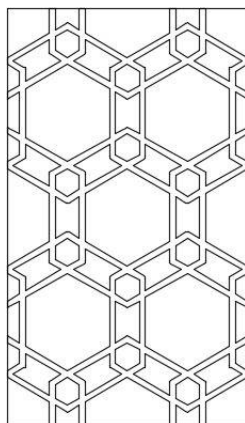
3.6.3.6 MUSTANSIRIYA MADRASA				
rbd %	$\theta = 30^\circ$	$\theta = 45^\circ$	$\theta = 60^\circ$	
1.0	4.92	4.83	5.12	
2.0	9.68	9.52	10.07	
3.0	14.28	14.07	14.87	
4.0	18.72	18.49	19.51	
5.0	23.00	22.76	23.98	
6.0	27.12	26.90	28.30	
7.0	31.08	30.90	32.45	
8.0	34.88	34.76	36.45	
9.0	38.52	38.48	40.29	

3.6.3.6 MUSTANSIRIYA MADRASA				
Sat. %	$\theta = 30^\circ$	$\theta = 45^\circ$	$\theta = 60^\circ$	
10	2.07	2.11	1.99	
15	3.16	3.21	3.03	
20	4.30	4.35	4.11	
25	5.49	5.54	5.24	
30	6.73	6.78	6.41	
35	8.03	8.07	7.64	
40	9.43	9.42	8.93	
45	10.90	10.85	10.29	
50	12.52	12.38	11.75	

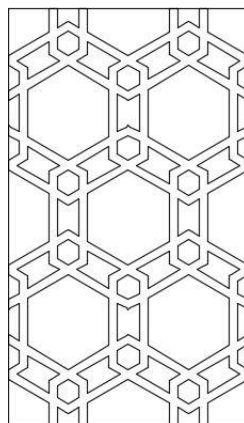
TABLE AP1.1.6. Saturation tables for tessellation 3.6.3.6.



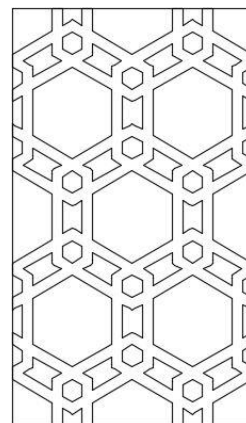
$\theta=30^\circ$ - rbd 2%



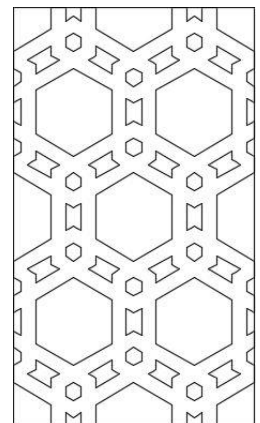
$\theta=30^\circ$ - rbd 5%



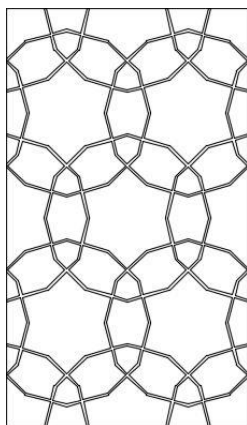
$\theta=30^\circ$ - rbd 7%



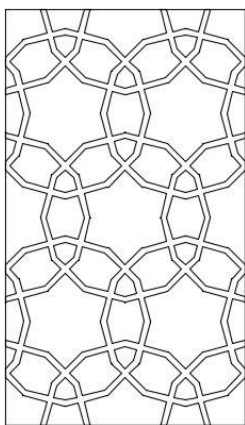
$\theta=30^\circ$ - rbd 9%



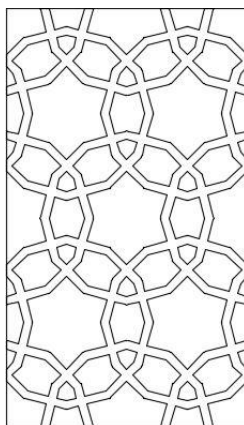
$\theta=30^\circ$ - rbd 12%



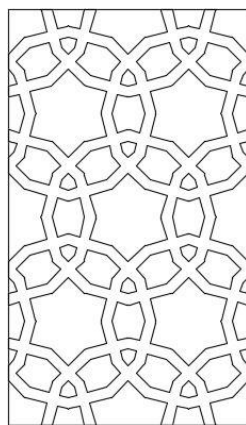
$\theta=45^\circ$ - rbd %



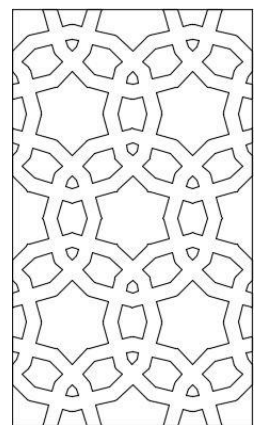
$\theta=45^\circ$ - rbd 5%



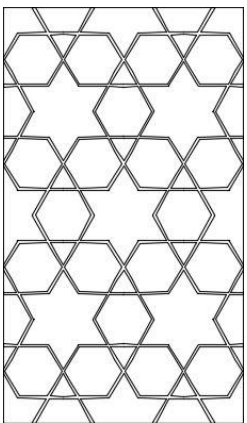
$\theta=45^\circ$ - rbd 7%



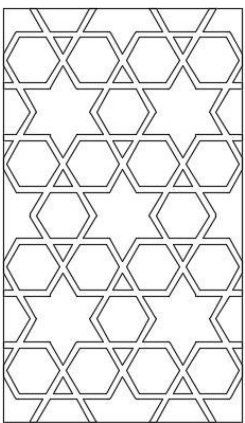
$\theta=45^\circ$ Rel beam 9%



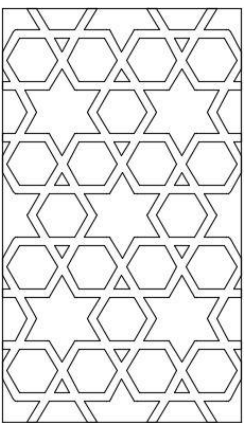
$\theta=45^\circ$ - rbd 12%



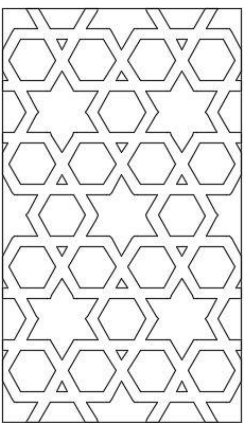
$\theta=60^\circ$ - rbd 2%



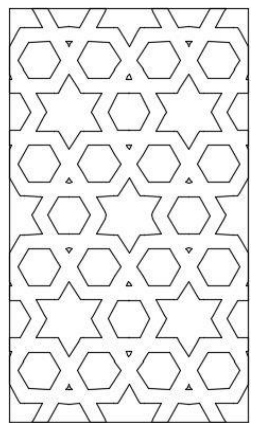
$\theta=60^\circ$ - rbd 5%



$\theta=60^\circ$ - rbd 7%



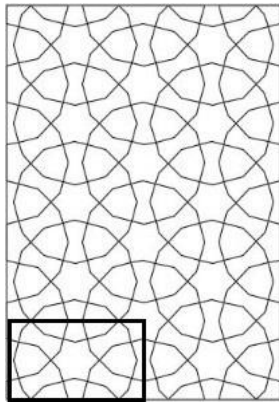
$\theta=60^\circ$ - rbd 9%



$\theta=60^\circ$ - rbd 12%

FIG AP1.1.6. Tessellation 3.6.3.6. different relative beam depths applied to the parametric variations

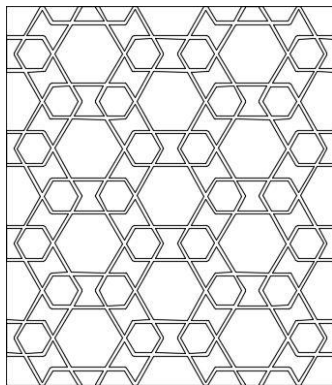
G) TOMB OF SALIM CHISHTI



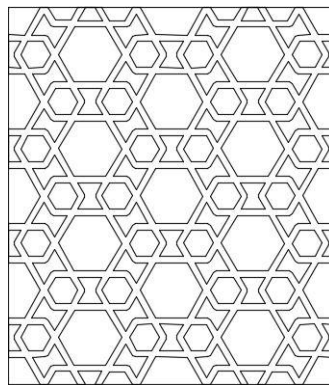
D6.6.6 TOMB OF SALIM CHISHTI			
rbd %	$\theta = 60^\circ$	$\theta = 75^\circ$	$\theta = 90^\circ$
1.0	9.08	9.45	10.54
2.0	17.69	18.49	20.61
3.0	25.82	27.11	30.19
4.0	33.47	35.32	39.29
5.0	40.64	43.10	47.91
6.0	47.34	50.48	56.05
7.0	53.55	57.45	X
8.0	59.29	63.99	X
9.0	X	X	X

D6.6.6 TOMB OF SALIM CHISHTI			
Sat. %	$\theta = 60^\circ$	$\theta = 75^\circ$	$\theta = 90^\circ$
10	1.11	1.06	0.95
15	1.69	1.61	1.44
20	2.28	2.18	1.94
25	2.90	2.76	2.46
30	3.55	3.35	2.98
35	4.21	3.96	3.53
40	4.91	4.60	4.08
45	5.65	5.26	4.66
50	6.43	5.94	5.26

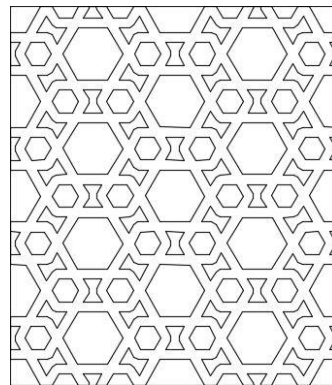
TABLE AP1.1.7. Saturation tables for tessellation 6.6.6. D = 65%



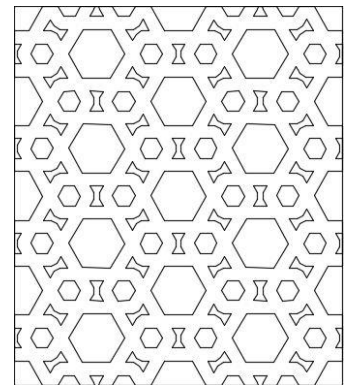
$\theta=60^\circ$ - rbd 2%



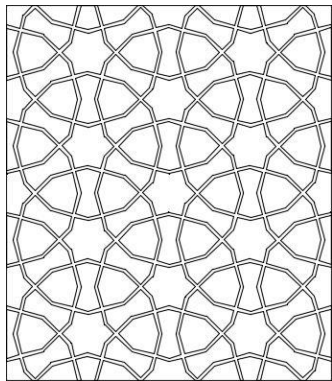
$\theta=60^\circ$ - rbd 4%



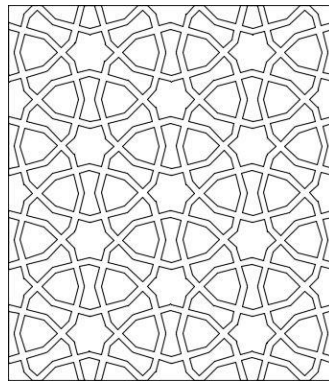
$\theta=60^\circ$ - rbd 6%



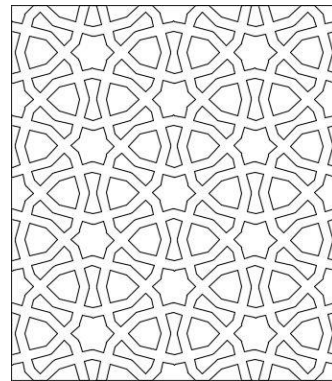
$\theta=60^\circ$ - rbd 8%



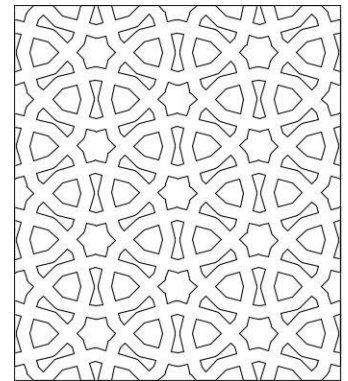
$\theta=75^\circ$ - rbd 2%



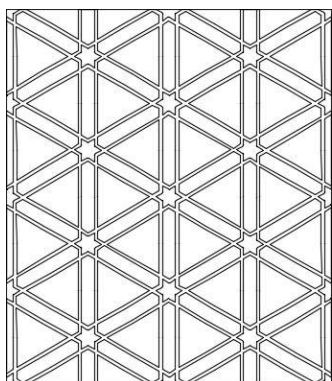
$\theta=75^\circ$ - rbd 4%



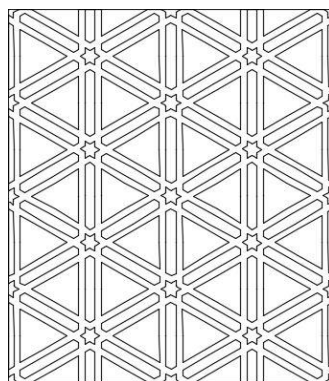
$\theta=75^\circ$ - rbd 6%



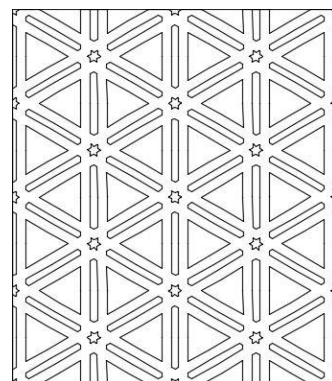
$\theta=75^\circ$ - rbd 8%



$\theta=90^\circ$ - rbd 2%



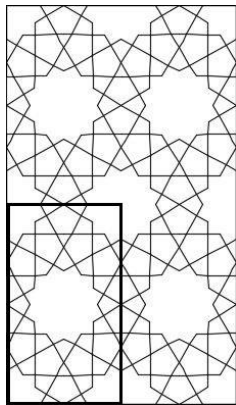
$\theta=90^\circ$ - rbd 4%



$\theta=90^\circ$ - rbd 6%

FIG AP1.1.7. Tessellation 6.6.6. D = 65%, different relative beam depths applied to the parametric variations

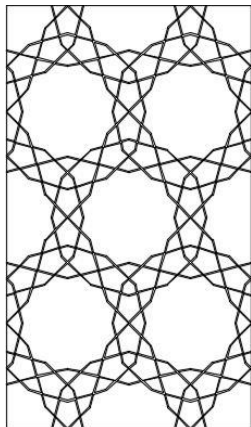
H) GENERALIFE



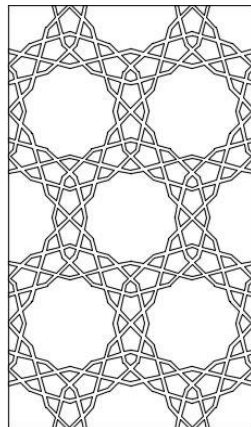
3.12.12 GENERALIFE			
rbd %	$\theta = 45^\circ$	$\theta = 60^\circ$	$\theta = 75^\circ$
1.0	7.87	8.67	10.39
2.0	15.21	16.82	20.05
3.0	22.02	24.46	28.97
4.0	28.31	31.58	X
5.0	34.07	38.18	X
6.0	39.30	44.26	X
7.0	44.00	49.83	X
8.0	48.17	X	X
9.0	51.82	X	X

3.12.12 GENERALIFE			
Sat. %	$\theta = 45^\circ$	$\theta = 60^\circ$	$\theta = 75^\circ$
10	1.29	1.16	0.96
15	1.97	1.78	1.48
20	2.70	2.42	2.00
25	3.47	3.08	2.56
30	4.29	3.78	3.12
35	5.18	4.52	X
40	6.15	5.30	X
45	7.24	6.13	X
50	8.50	7.03	X

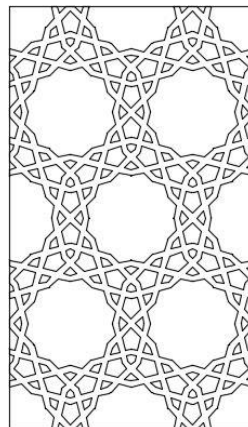
TABLE AP1.1.8. Saturation tables for tessellation 3.12.12.



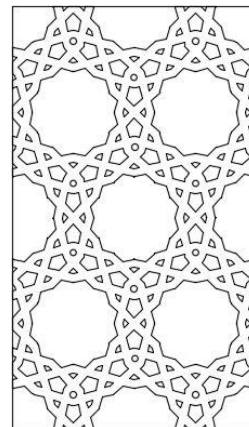
$\theta=45^\circ$ - rbd 1%



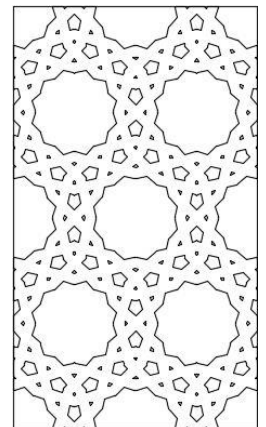
$\theta=45^\circ$ - rbd 3%



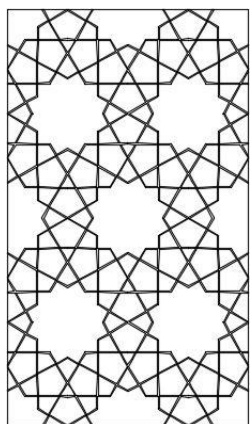
$\theta=45^\circ$ - rbd 5%



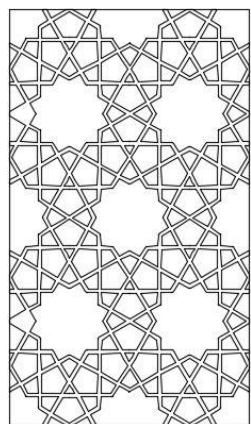
$\theta=45^\circ$ - rbd 7%



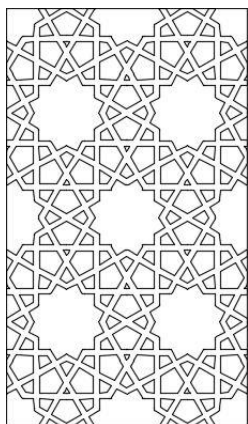
$\theta=45^\circ$ - rbd 9%



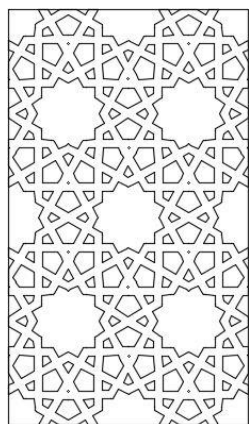
$\theta=60^\circ$ - rbd 1%



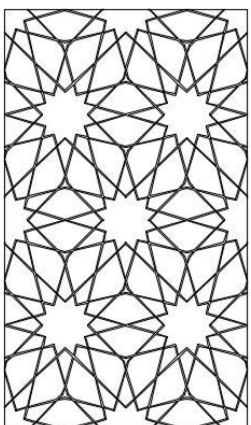
$\theta=60^\circ$ - rbd 3%



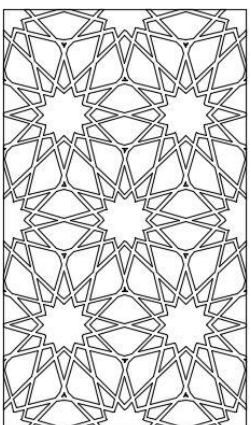
$\theta=60^\circ$ - rbd 5%



$\theta=60^\circ$ - rbd 7%



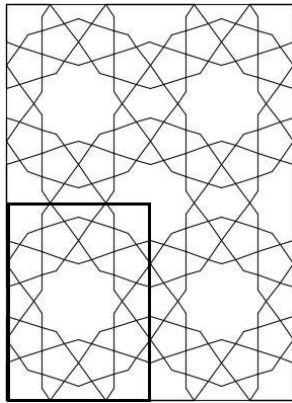
$\theta=75^\circ$ - rbd 1%



$\theta=75^\circ$ - rbd 3%

FIG AP1.1.8. Tessellation 3.12.12. different relative beam depths applied to the parametric variations

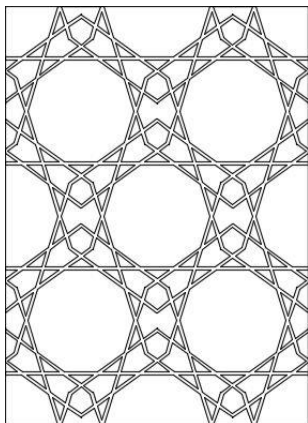
I) HASHT BEHESHT



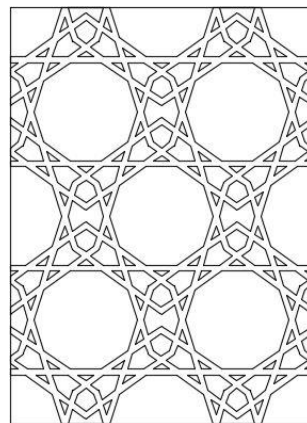
I-6.10.10 HASHT BEHESHT			
rbd %	$\theta = 36^\circ$	$\theta = 54^\circ$	$\theta = 72^\circ$
1.0	8.57	8.89	10.18
2.0	16.41	17.23	19.65
3.0	23.51	25.03	28.43
4.0	29.87	32.27	36.50
5.0	35.49	38.96	43.88
6.0	40.37	45.10	X
7.0	44.51	50.69	X
8.0	X	55.74	X
9.0	X	60.23	X

I-6.10.10 HASHT BEHESHT			
Sat. %	$\theta = 36^\circ$	$\theta = 54^\circ$	$\theta = 72^\circ$
10	1.18	1.13	0.98
15	1.82	1.73	1.51
20	2.51	2.35	2.04
25	3.23	3.00	2.61
30	4.02	3.69	3.19
35	4.91	4.41	3.81
40	5.92	5.17	4.47
45	7.12	5.98	5.15
50	X	6.88	X

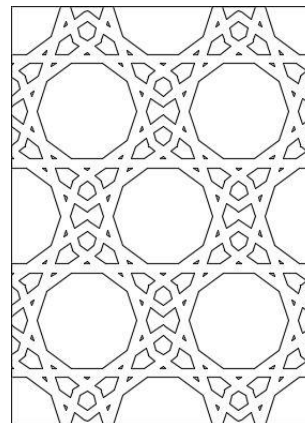
TABLE AP1.1.9.Saturation tables for tessellation I-6.10.10.



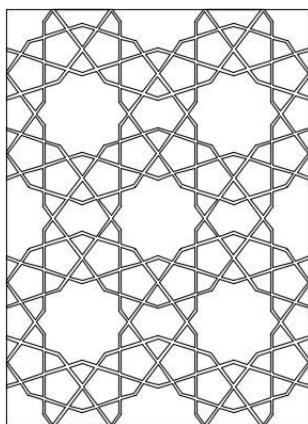
$\theta=36^\circ$ - rbd 2%



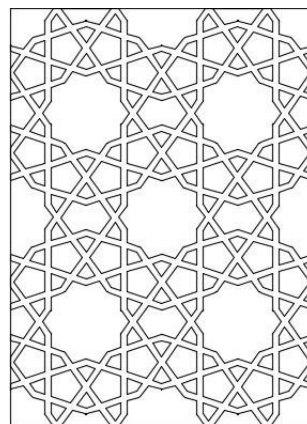
$\theta=36^\circ$ - rbd 4%



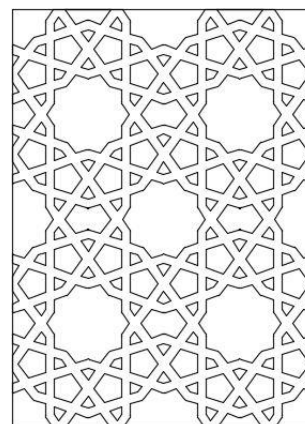
$\theta=36^\circ$ - rbd 6%



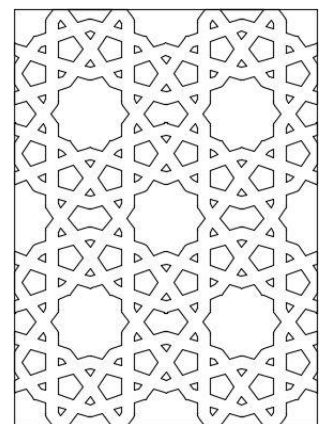
$\theta=54^\circ$ - rbd 2%



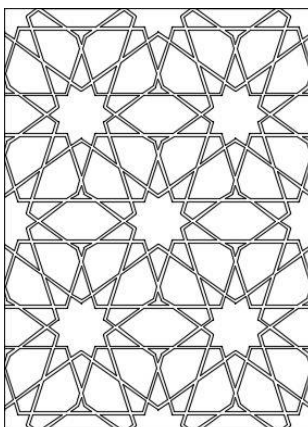
$\theta=54^\circ$ - rbd 4%



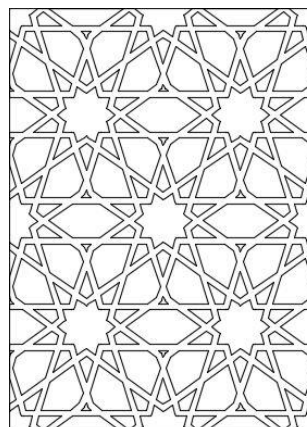
$\theta=54^\circ$ - rbd 6%



$\theta=54^\circ$ - rbd 8%



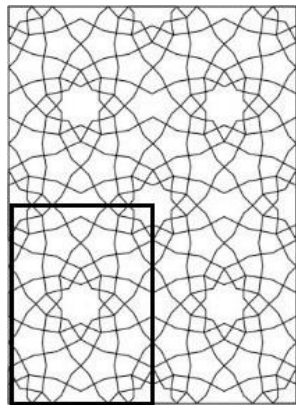
$\theta=72^\circ$ - rbd 2%



$\theta=72^\circ$ - rbd 4%

FIG AP1.1.9. Tessellation I-6.10.10. different relative beam depths applied to the parametric variations

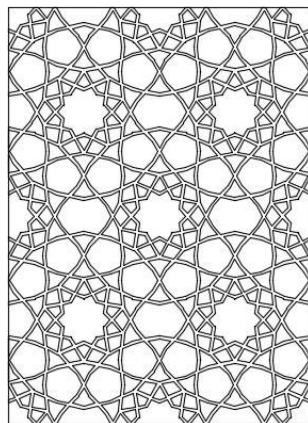
J) MODARI-KHAN MADRASH



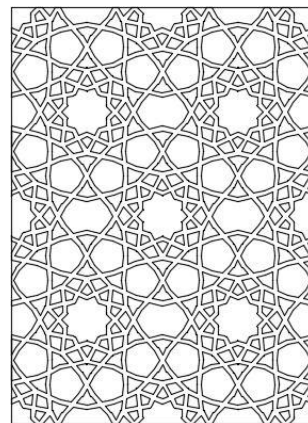
ROS_H6.10.10 MODARI-KHAN MADRASH			
rbd %	$\theta_1 = 30^\circ$	$\theta_1 = 45^\circ$	$\theta_1 = 60^\circ$
1.0	13.60	13.49	13.97
1.5	19.93	19.82	20.50
2.0	25.97	25.86	26.73
2.5	31.68	31.61	32.66
3.0	37.10	37.09	38.29
3.5	42.18	42.28	43.62
4.0	47.00	47.19	48.64
4.5	51.45	51.81	53.37
5.0	55.66	56.16	57.79

ROS-I-6.10.10 MODARI-KHAN MADRASH			
Sat. %	$\theta_1 = 30^\circ$	$\theta_1 = 45^\circ$	$\theta_1 = 60^\circ$
10	0.73	0.74	0.71
15	1.11	1.12	1.08
20	1.51	1.52	1.46
25	1.92	1.93	1.86
30	2.35	2.36	2.28
35	2.81	2.81	2.71
40	3.29	3.28	3.16
45	3.79	3.78	3.64
50	4.34	4.30	4.14

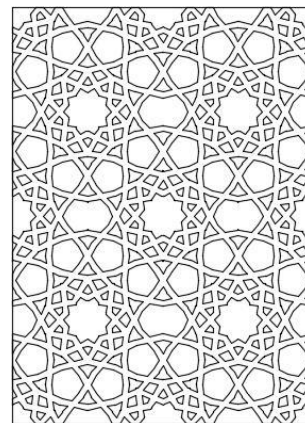
TABLE AP1.1.10. Saturation tables for tessellation ROS-I-6.10.10. $\theta_1 = 45^\circ$



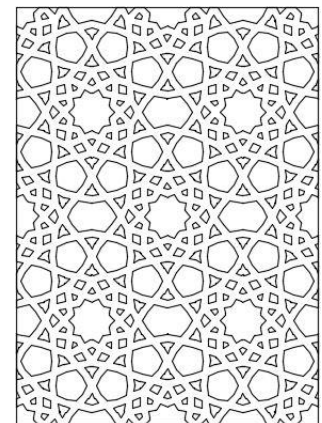
$\theta_1=30^\circ$ - rbd 2%



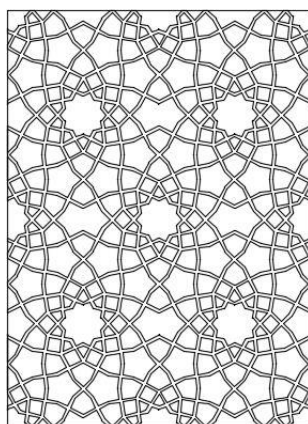
$\theta_1=30^\circ$ - rbd 3%



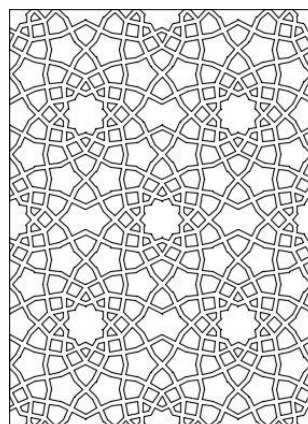
$\theta_1=30^\circ$ - R rbd 4%



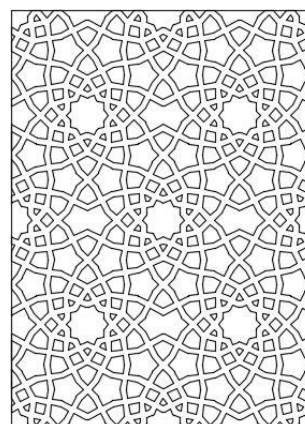
$\theta_1=30^\circ$ - rbd 5%



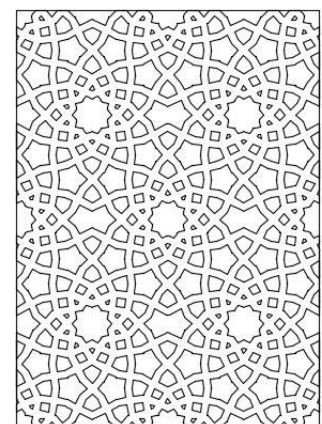
$\theta_1=45^\circ$ - rbd 2%



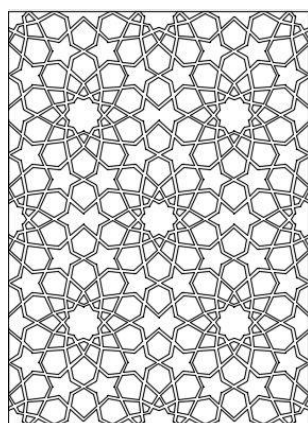
$\theta_1=45^\circ$ - rbd 3%



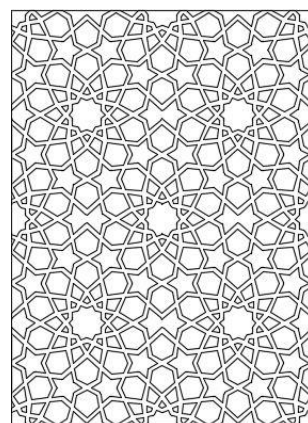
$\theta_1=45^\circ$ - rbd 4%



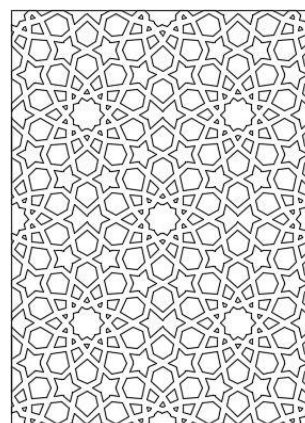
$\theta_1=45^\circ$ - rbd 5%



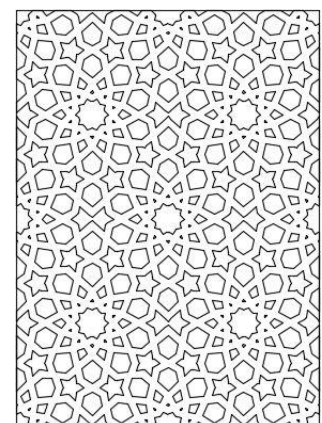
$\theta_1=60^\circ$ - rbd 2%



$\theta_1=60^\circ$ - rbd 3%



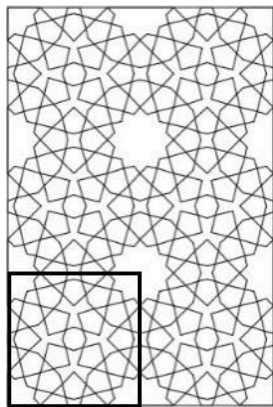
$\theta_1=60^\circ$ - rbd 4%



$\theta_1=60^\circ$ - Re rbd 5%

FIG AP1.1.10. Tessellation ROS-I-6.10.10. $\theta_1 = 45^\circ$, different relative beam depths applied to the parametric variations

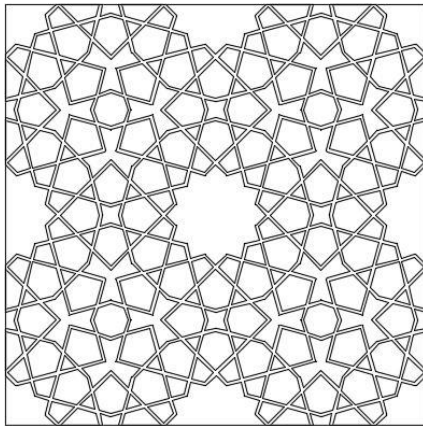
K) COMPLEX OF SULTAN BAYEZID II



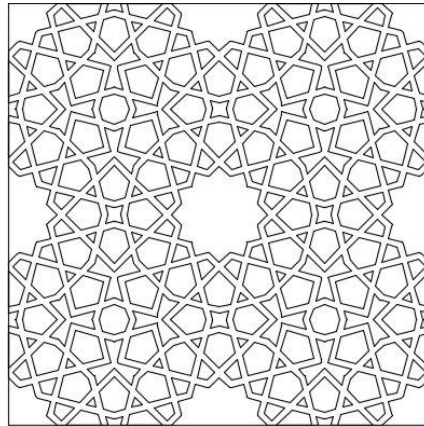
ROS_3.4.3.12.3.12.12 SULTAN BAYEZID II			
rbd %	$\theta = 60^\circ$	$\theta = 67.5^\circ$	$\theta = 75^\circ$
1.0	13.68	13.48	13.64
1.5	20.08	19.78	19.96
2.0	26.19	25.78	25.95
2.5	32.01	31.48	31.61
3.0	37.54	36.88	36.93
3.5	42.77	41.99	41.91
4.0	47.72	46.79	X
4.5	52.37	51.30	X
5.0	56.73	X	X

ROS_3.4.3.12.3.12.12 SULTAN BAYEZID II			
Sat. %	$\theta = 60^\circ$	$\theta = 67.5^\circ$	$\theta = 75^\circ$
10	0.73	0.74	0.73
15	1.10	1.12	1.11
20	1.49	1.52	1.50
25	1.90	1.94	1.92
30	2.33	2.37	2.36
35	2.77	2.83	2.82
40	3.24	3.31	3.31
45	3.73	3.81	X
50	4.25	4.36	X

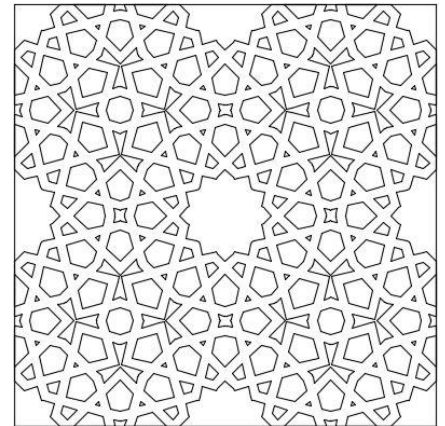
TABLE AP1.1.11. Saturation tables for tessellation ROS-3.4.3.12_3.12.12.



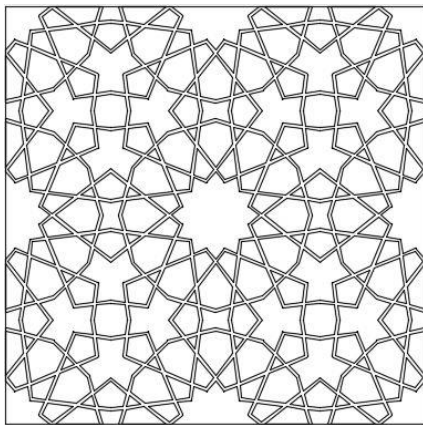
$\theta=60^\circ$ - rbd 1.5%



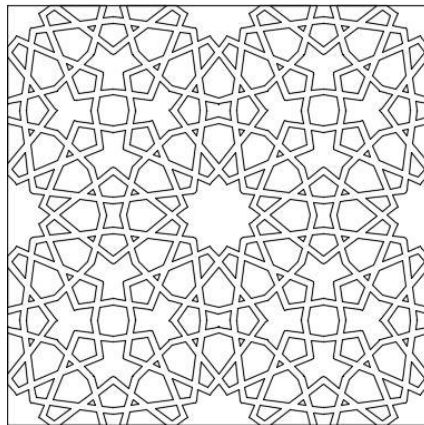
$\theta=60^\circ$ - rbd 3%



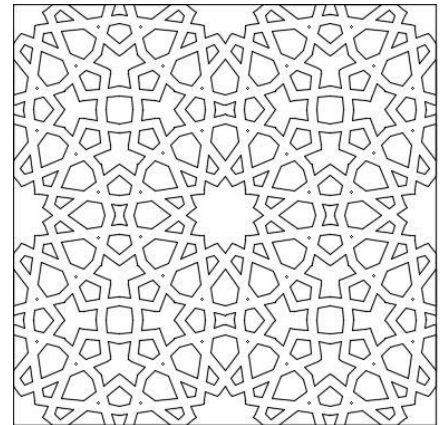
$\theta=60^\circ$ - rbd 4.5%



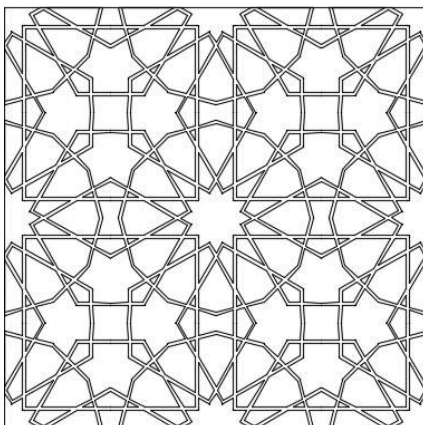
$\theta=67.5^\circ$ - rbd 1.5%



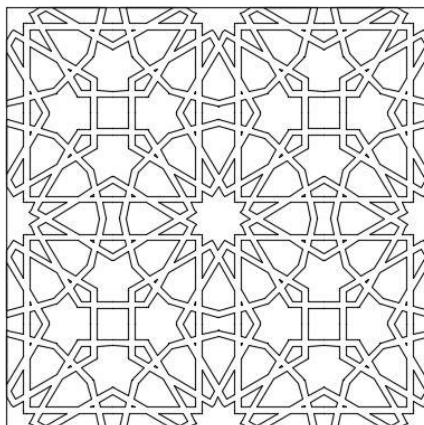
$\theta=67.5^\circ$ - rbd 3%



$\theta=67.5^\circ$ - rbd 4.5%



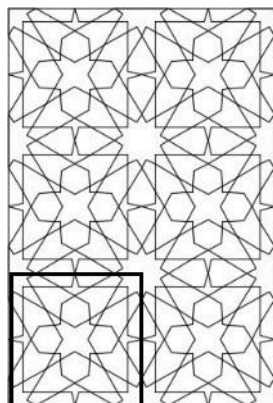
$\theta=75^\circ$ - rbd 1.5%



$\theta=75^\circ$ - rbd 3%

FIG AP1.1.11. Tessellation ROS-3.4.3.12_3.12.12. different relative beam depths applied to the parametric variations

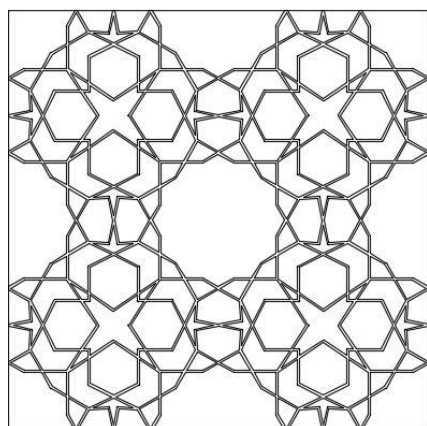
L) BEN YUSUF MADRASA



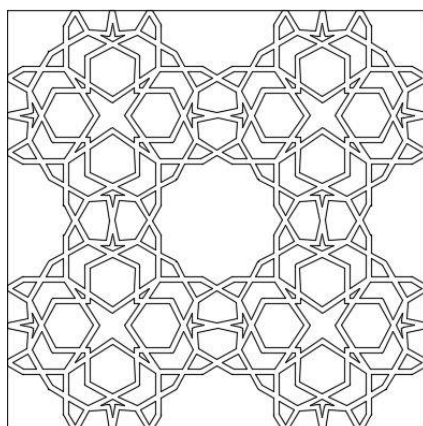
ROS-3.4.3.12.3.12.12 BEN YUSUF MADRASA			
rbd %	$\theta_2 = 45^\circ$	$\theta_2 = 60^\circ$	$\theta_2 = 75^\circ$
0.5	5.91	6.19	6.79
1.0	11.54	12.12	13.28
1.5	16.91	17.77	19.46
2.0	22.00	23.15	25.33
2.5	26.81	28.27	30.91
3.0	31.36	33.11	36.17
3.5	35.63	37.68	41.14
4.0	39.63	41.99	45.79
4.5	X	X	X

ROS-3.4.3.12.3.12.12 BEN YUSUF MADRASA			
Sat. %	$\theta_2 = 45^\circ$	$\theta_2 = 60^\circ$	$\theta_2 = 75^\circ$
10	0.86	0.82	0.75
15	1.32	1.26	1.14
20	1.80	1.71	1.55
25	2.31	2.18	1.97
30	2.85	2.68	2.42
35	3.43	3.21	2.89
40	4.05	3.77	3.39
45	X	X	3.91
50	X	X	X

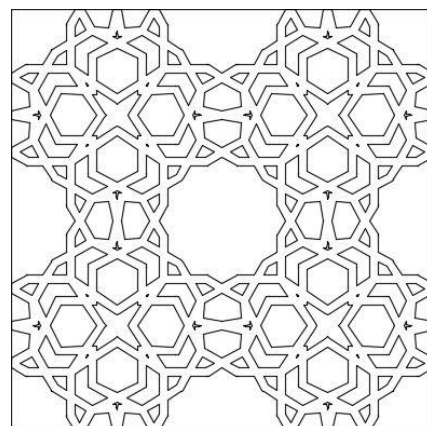
TABLE AP1.1.12. Saturation tables for tessellation ROS-3.4.3.12_3.12.12. $\theta_1 = 78.5^\circ$



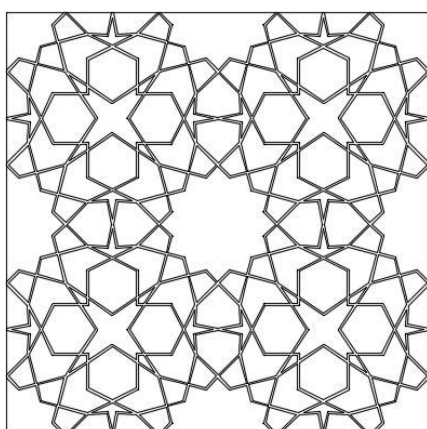
$\theta_2 = 45^\circ$ - rbd 1%



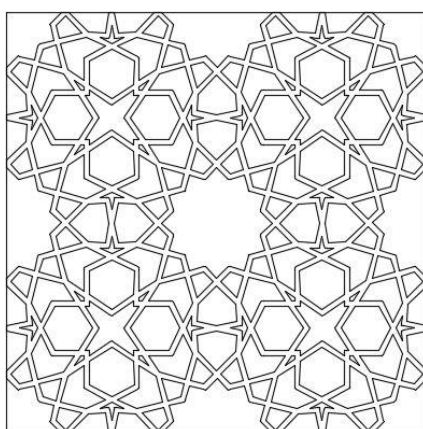
$\theta_2 = 45^\circ$ - rbd 2.5%



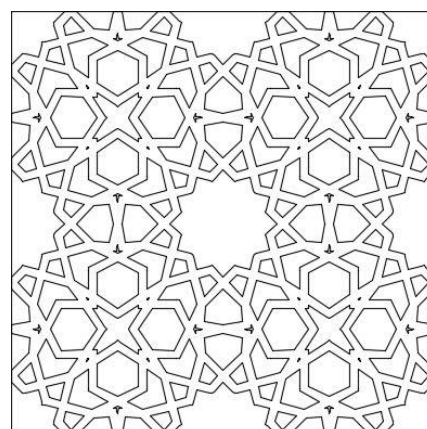
$\theta_2 = 45^\circ$ - rbd 4%



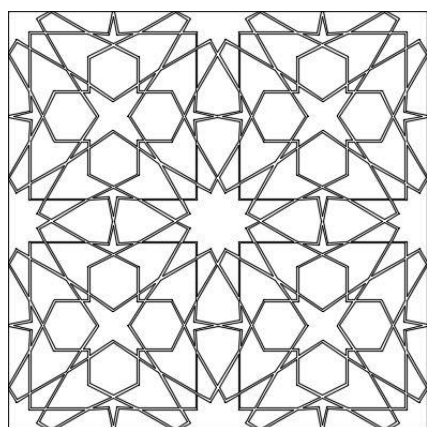
$\theta_2 = 60^\circ$ - rbd 1%



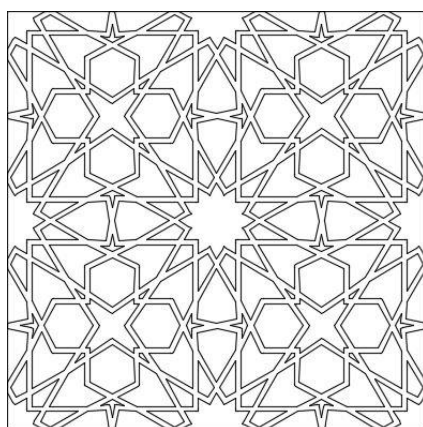
$\theta_2 = 60^\circ$ - rbd 2.5%



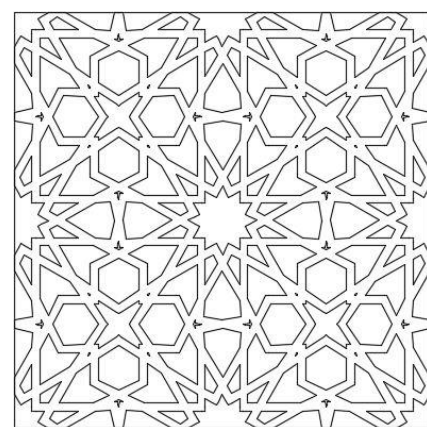
$\theta_2 = 60^\circ$ - rbd 4%



$\theta_2 = 75^\circ$ - rbd 1%



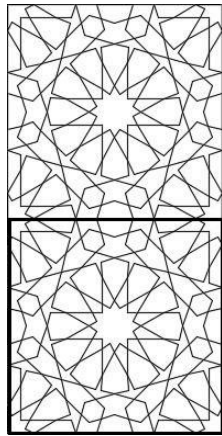
$\theta_2 = 75^\circ$ - rbd 2.5%



$\theta_2 = 75^\circ$ - rbd 4%

FIG AP1.1.12. Tessellation ROS-3.4.3.12_3.12.12. $\theta_1 = 78.5^\circ$, different relative beam depths applied to the parametric variations

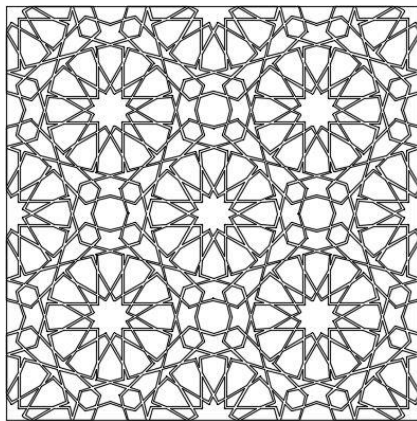
M) AL-NASIR MUHAMMAD'S MINBAR



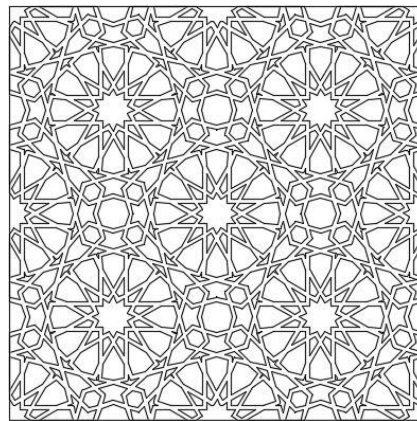
ROS_H6.12.8.12 AL-NASIR MUHAMMAD MINBAR			
rbd %	L = 20%	L = 35%	L = 50%
0.5	11.13	11.38	11.63
1.0	21.42	21.82	22.22
1.5	30.88	31.32	31.78
2.0	39.51	39.89	40.29
2.5	47.30	47.52	47.77
3.0	54.25	54.23	X
3.5	X	X	X
4.0	X	X	X
4.5	X	X	X

ROS_H6.12.8.12 AL-NASIR MUHAMMAD MINBAR			
Sat. %	L = 20%	L = 35%	L = 50%
10	0.45	0.43	0.42
15	0.69	0.67	0.66
20	0.93	0.91	0.90
25	1.19	1.17	1.15
30	1.45	1.43	1.41
35	1.74	1.71	1.69
40	2.03	2.01	1.98
45	2.35	2.33	2.31
50	2.69	2.68	2.65

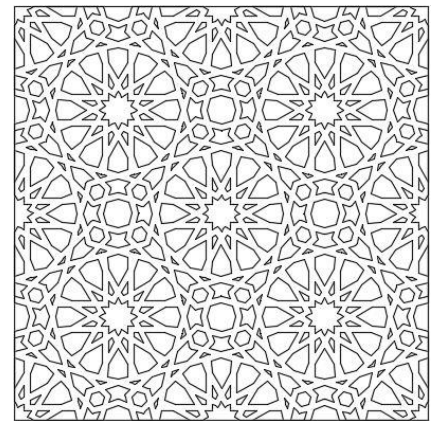
TABLE AP1.1.13. Saturation tables for tessellation ROS-I-6.12.8.12. $\theta = 75^\circ$



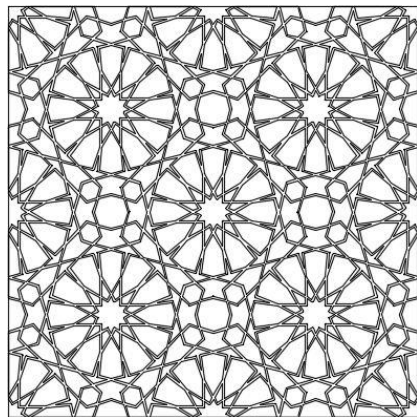
L=20% - rbd 1%



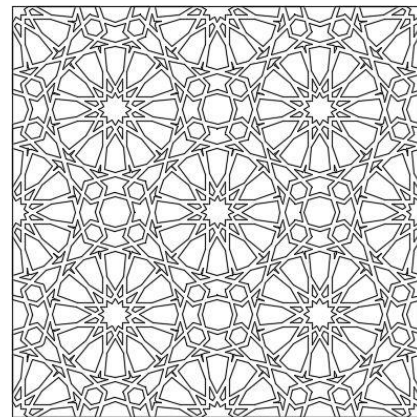
L=20% - rbd 2%



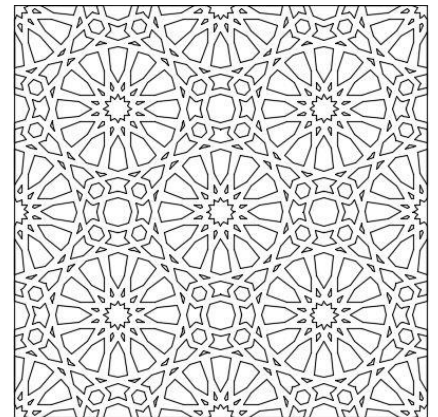
L=20% - rbd 3%



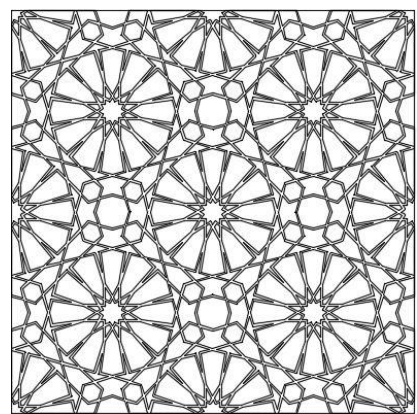
L=35% - rbd 1%



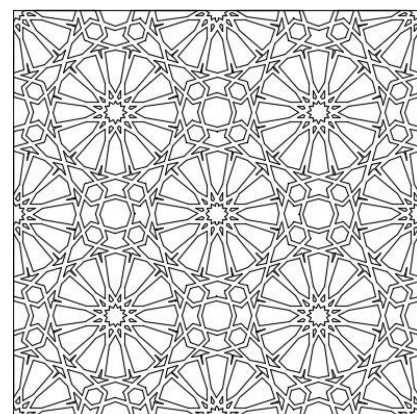
L=35% - rbd 2%



L=35% - rbd 3%



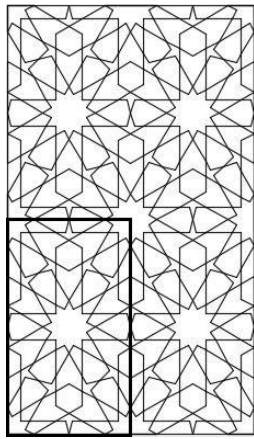
L=50% - rbd 1%



L=50% - rbd 2%

FIG AP1.1.13. Tessellation ROS-I-6.12.8.12. $\theta = 75^\circ$. different relative beam depths applied to the parametric variations

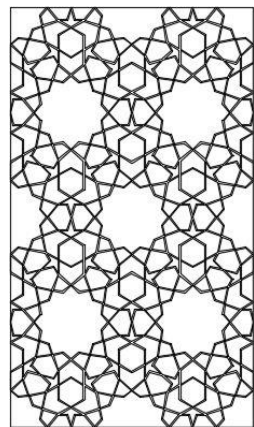
N) MOSQUE OF AL-NASIR MUHAMMAD



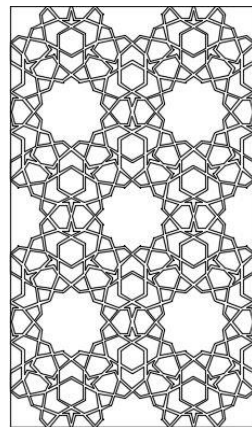
ROS-3.12.12 MOSQUE OF AL-NASIR MUHAMMAD			
rbd %	$\theta_2 = 55^\circ$	$\theta_2 = 65^\circ$	$\theta_2 = 75^\circ$
1.0	11.71	12.35	13.38
1.5	17.19	18.14	19.51
2.0	22.41	23.67	25.59
2.5	27.39	28.94	31.25
3.0	32.12	33.95	36.62
3.5	36.59	38.70	41.60
4.0	40.81	43.19	46.57
4.5	44.79	47.42	50.97
5.0	48.51	51.39	55.17

ROS-3.12.12 MOSQUE OF AL-NASIR MUHAMMAD			
Sat. %	$\theta_2 = 55^\circ$	$\theta_2 = 65^\circ$	$\theta_2 = 75^\circ$
10	0.85	0.81	0.74
15	1.30	1.23	1.13
20	1.77	1.67	1.54
25	2.26	2.13	1.95
30	2.78	2.61	2.39
35	3.32	3.11	2.85
40	3.90	3.65	3.34
45	4.53	4.21	3.84
50	5.21	4.83	4.39

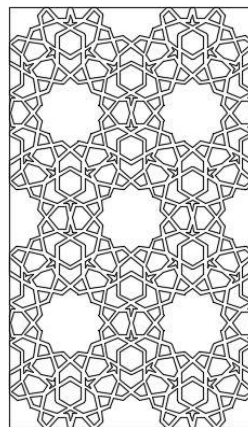
TABLE AP1.1.14. Saturation tables for tessellation ROS-3.12.12. $\theta = 75^\circ$



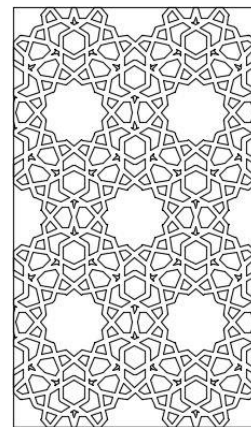
$\theta = 55^\circ$ - rbd 1%



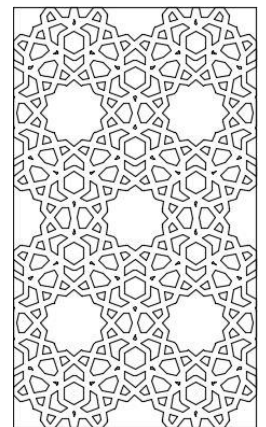
$\theta = 55^\circ$ - rbd 2%



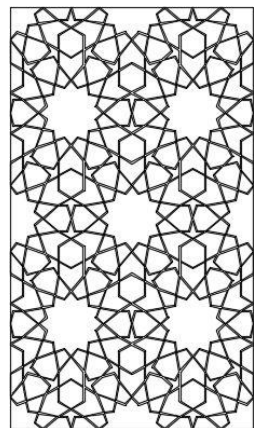
$\theta = 55^\circ$ - rbd 3%



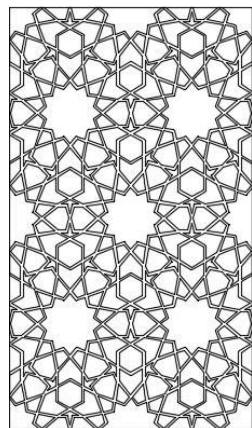
$\theta = 55^\circ$ - rbd 4%



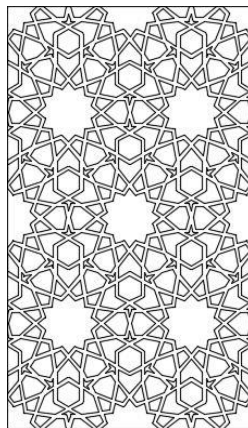
$\theta = 55^\circ$ - rbd 5%



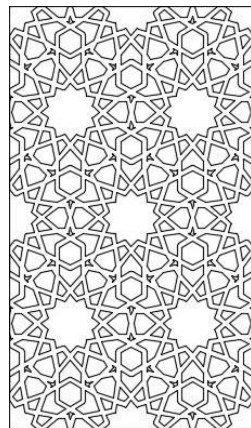
$\theta = 65^\circ$ - rbd 1%



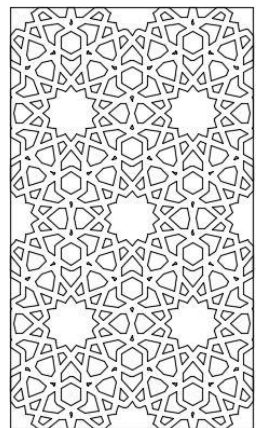
$\theta = 65^\circ$ - rbd 2%



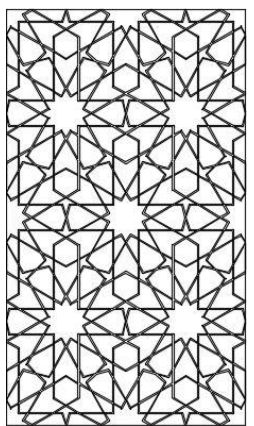
$\theta = 65^\circ$ - rbd 3%



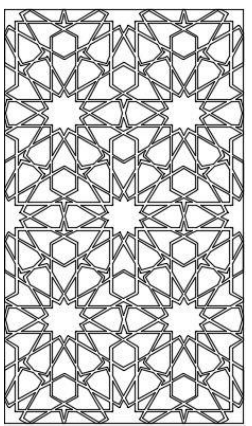
$\theta = 65^\circ$ - rbd 4%



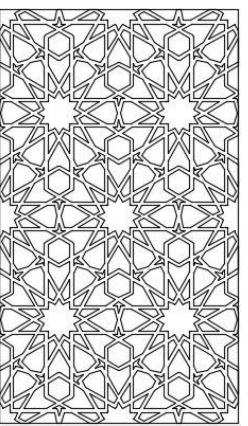
$\theta = 65^\circ$ - rbd 5%



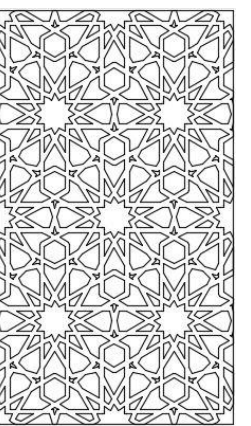
$\theta = 75^\circ$ - rbd 1%



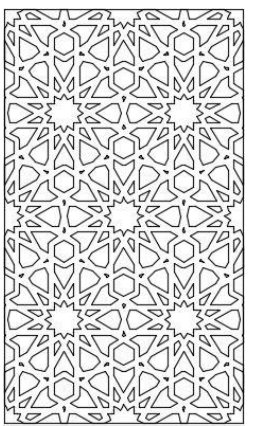
$\theta = 75^\circ$ - rbd 2%



$\theta = 75^\circ$ - rbd 3%



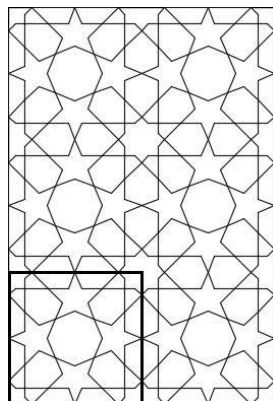
$\theta = 75^\circ$ - rbd 4%



$\theta = 75^\circ$ - rbd 5%

FIG AP1.1.14. Tessellation ROS-3.12.12. $\theta = 75^\circ$ different relative beam depths applied to the parametric variations

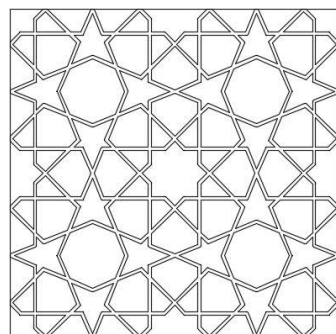
O) GREAT MOSQUE OF HERAT



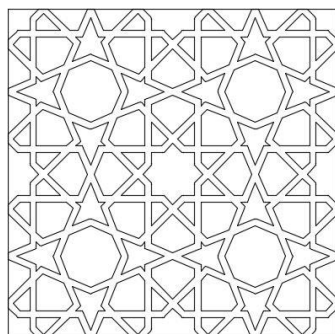
ROS_4.8.8 GREAT MOSQUE OF HERAT			
rbd %	L = 15%	L = 22.5%	L = 30%
1.0	9.59	9.54	9.48
2.0	18.63	18.52	18.41
3.0	27.02	26.95	26.79
4.0	35.04	34.82	34.61
5.0	42.05	42.14	41.87
6.0	49.23	48.90	48.58
7.0	55.49	55.11	54.73
8.0	61.19	60.76	60.33
9.0	X	65.86	X

ROS_4.8.8 GREAT MOSQUE OF HERAT			
Sat. %	L = 15%	L = 22.5%	L = 30%
10	1.05	1.05	1.06
15	1.60	1.61	1.62
20	2.16	2.18	2.19
25	2.76	2.77	2.79
30	3.37	3.39	3.41
35	4.00	4.02	4.05
40	4.71	4.71	4.74
45	5.41	5.42	5.47
50	6.12	6.18	6.23

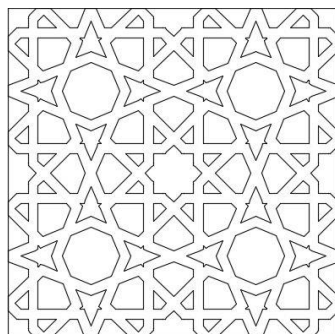
TABLE AP1.1.15. Saturation tables for tessellation ROS-4.8.8. $\theta = 67.5^\circ$



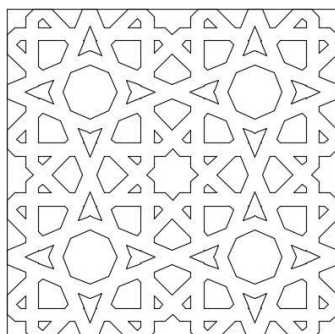
L = 15% - rbd 2%



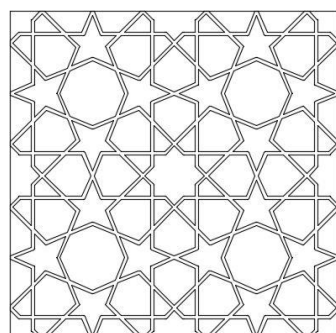
L = 15% - rbd 4%



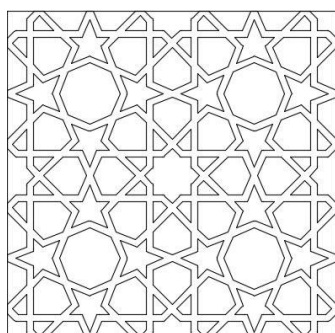
L = 15% - rbd 6%



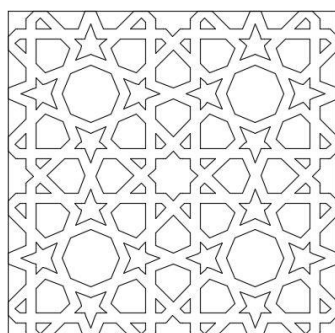
L = 15% - rbd 8%



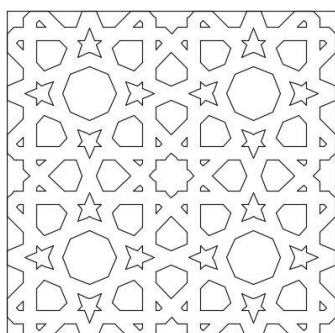
L = 22.5% - rbd 2%



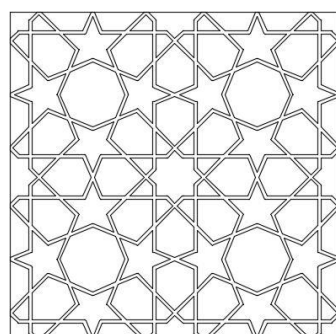
L = 22.5% - rbd 4%



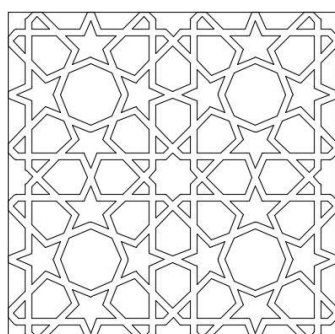
L = 22.5% - rbd 6%



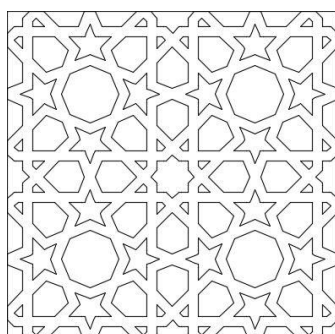
L = 22.5% - rbd 8%



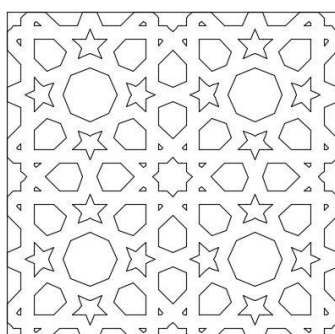
L = 30% - rbd 2%



L = 30% - rbd 4%



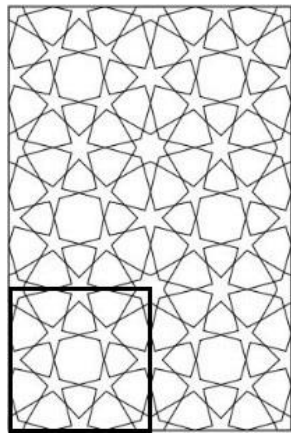
L = 30% - rbd 6%



L = 30% - rbd 8%

FIG AP1.1.15. Tessellation ROS-4.8.8. $\theta = 67.5^\circ$ different relative beam depths applied to the parametric variations

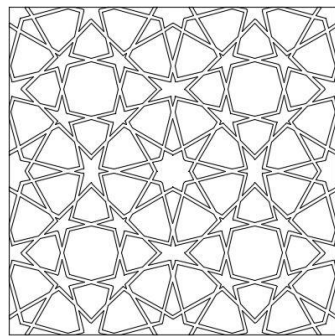
P) MOSQUE OF AL-SALIH TALA'I



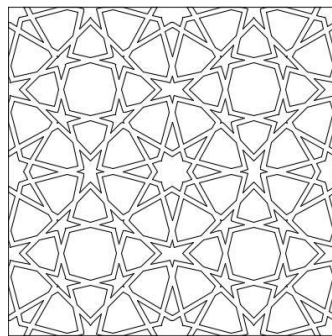
ROS-3.4.3.8.3.8.8 MOSQUE OF AL-SALIH TALA'I			
rbd %	L = 15%	L = 25%	L = 35%
1.0	11.97	11.92	11.87
2.0	22.99	22.88	22.78
3.0	33.15	32.89	32.73
4.0	42.15	41.94	41.72
5.0	50.32	50.02	49.76
6.0	57.58	57.15	X
7.0	X	X	X
8.0	X	X	X
9.0	X	X	X

ROS-3.4.3.8.3.8.8 MOSQUE OF AL-SALIH TALA'I			
Sat. %	L = 15%	L = 25%	L = 35%
10	0.82	0.82	0.83
15	1.27	1.28	1.00
20	1.73	1.74	1.75
25	2.20	2.21	2.22
30	2.69	2.71	2.73
35	3.21	3.23	3.25
40	3.76	3.79	3.81
45	4.35	4.38	4.41
50	4.96	5.00	5.03

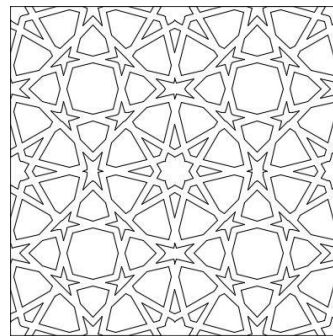
TABLE AP1.1.16. Saturation tables for tessellation ROS-3.4.3.8_3.8.8. $\theta = 75^\circ$



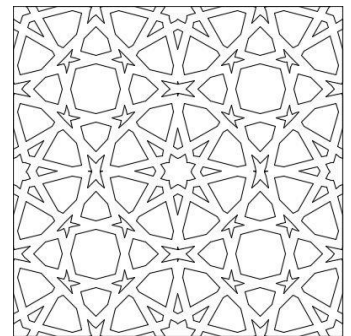
L = 15% - rbd 2%



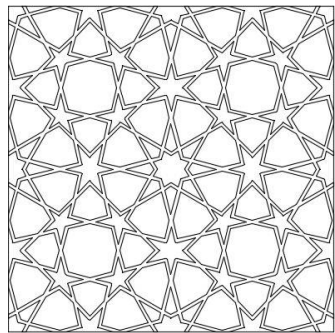
L = 15% - rbd 3%



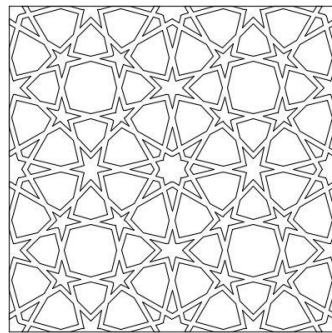
L = 15% - rbd 4%



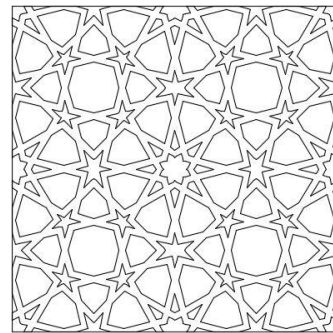
L = 15% - rbd 5%



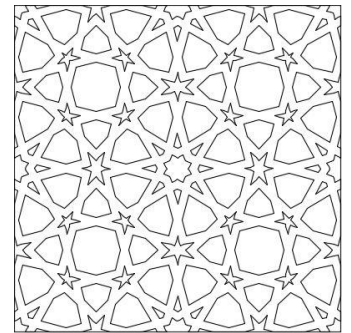
L = 25% - rbd 2%



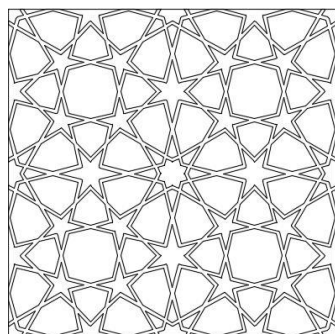
L = 25% - rbd 3%



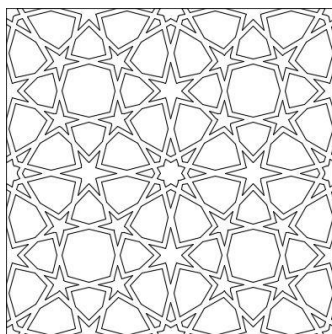
L = 25% - rbd 4%



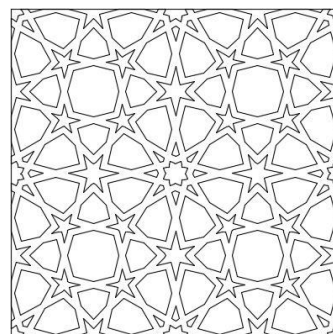
L = 25% - rbd 5%



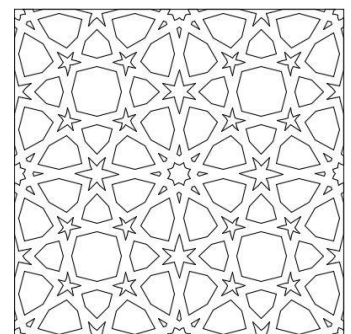
L = 35% - rbd 2%



L = 35% - rbd 3%



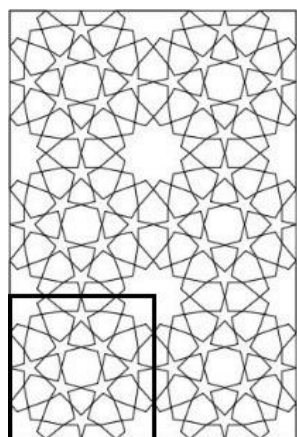
L = 35% - rbd 4%



L = 35% - rbd 5%

FIG AP1.1.16. Tessellation ROS-3.4.3.8_3.8.8. $\theta = 75^\circ$ different relative beam depths applied to the parametric variations

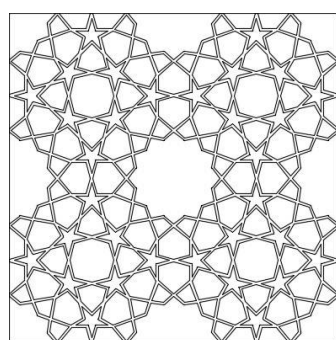
Q) MOSQUE OF IBN TULUN



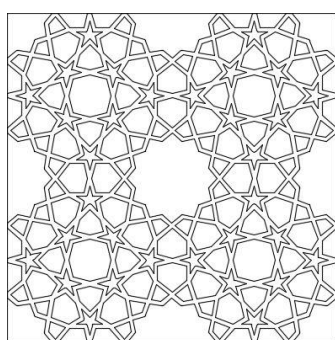
ROS-3.4.3.12.3.12.12 MOSQUE OF IBN TULUN			
rbd %	$\theta_2 = 55^\circ$	$\theta_2 = 65^\circ$	$\theta_2 = 75^\circ$
0.5	6.43	6.70	7.13
1.0	12.57	13.10	13.93
1.5	18.41	19.19	20.41
2.0	23.96	24.99	26.55
2.5	29.23	30.49	32.37
3.0	34.19	35.69	37.85
3.5	38.87	40.59	43.01
4.0	43.25	45.18	47.83
4.5	47.34	49.48	52.33

ROS-3.4.3.12.3.12.12 MOSQUE OF IBN TULUN			
Sat. %	$\theta_2 = 55^\circ$	$\theta_2 = 65^\circ$	$\theta_2 = 75^\circ$
10	0.79	0.76	0.71
15	1.21	1.16	1.08
20	1.64	1.57	1.47
25	2.10	2.00	1.87
30	2.58	2.46	2.30
35	3.09	2.93	2.74
40	3.63	3.44	3.21
45	4.21	3.98	3.71
50	4.82	4.56	4.24

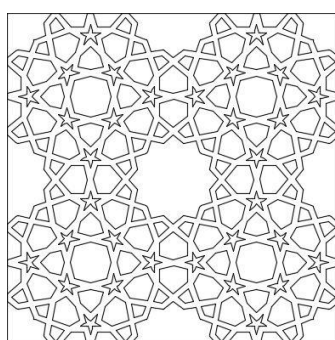
TABLE AP1.1.17. Saturation tables for tessellation ROS-3.4.3.12_3.12.12. $\theta_1=75^\circ$.



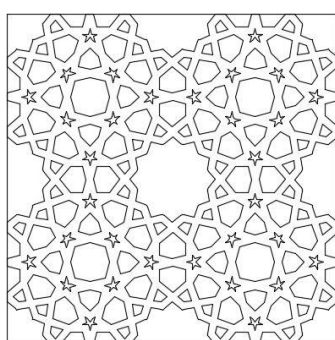
$\theta=55^\circ$ - rbd 1.5%



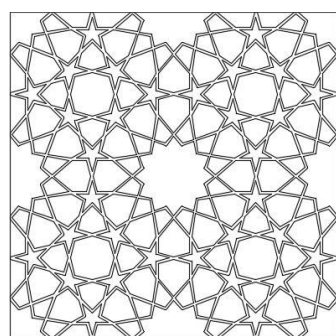
$\theta=55^\circ$ - rbd 2.5%



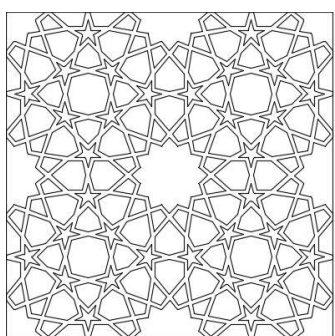
$\theta=55^\circ$ - rbd 3.5%



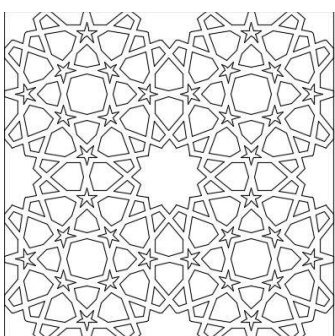
$\theta=55^\circ$ - rbd 4.5%



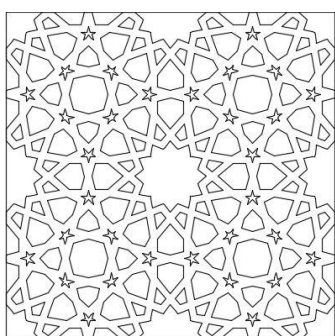
$\theta=65^\circ$ - rbd 1.5%



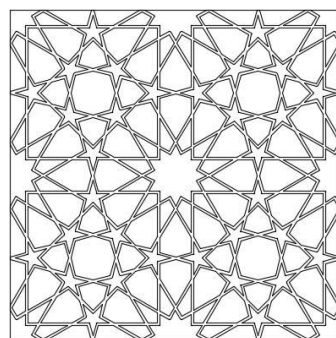
$\theta=65^\circ$ - rbd 2.5%



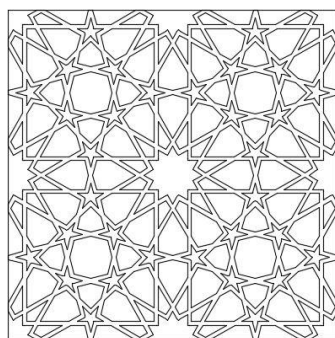
$\theta=65^\circ$ - rbd 3.5%



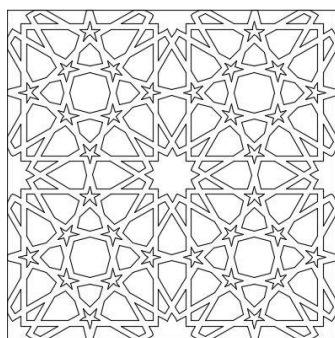
$\theta=65^\circ$ - rbd 4.5%



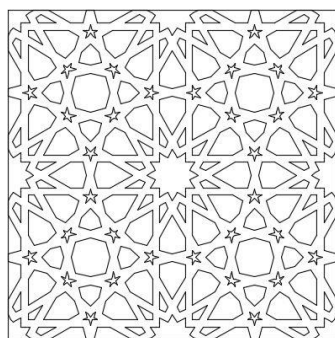
$\theta=75^\circ$ - rbd 1.5%



$\theta=75^\circ$ - rbd 2.5%



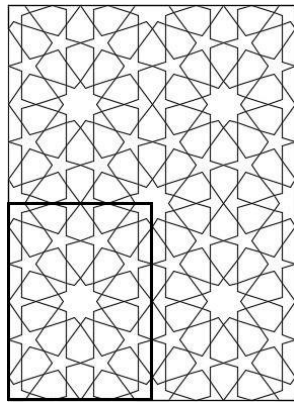
$\theta=75^\circ$ - rbd 3.5%



$\theta=75^\circ$ - rbd 4.5%

FIG AP1.1.17. Tessellation ROS-3.4.3.12_3.12.12. $\theta_1=75^\circ$, different relative beam depths applied to the parametric variations

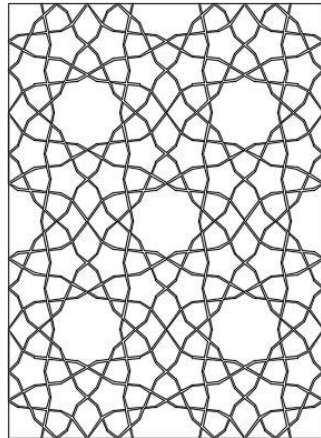
R) FATEHPUR SIKRI



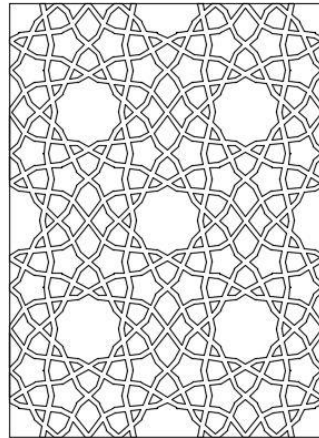
ROS-I-6.10.10 FATEHPUR SIKRI			
rbd %	$\theta = 48^\circ$	$\theta = 60^\circ$	$\theta = 72^\circ$
1.0	11.68	12.46	13.86
2.0	22.46	23.97	26.49
3.0	32.35	34.55	37.90
4.0	41.33	44.19	48.08
5.0	49.41	52.90	57.03
6.0	56.58	60.66	64.76
7.0	62.86	67.49	X
8.0	X	X	X
9.0	X	X	X

ROS-I-6.10.10 FATEHPUR SIKRI			
Sat. %	$\theta = 48^\circ$	$\theta = 60^\circ$	$\theta = 72^\circ$
10	0.84	0.79	0.69
15	1.31	1.22	1.09
20	1.77	1.66	1.49
25	2.26	2.10	1.88
30	2.76	2.57	2.31
35	3.30	3.05	2.75
40	3.85	3.57	3.21
45	4.45	4.09	3.70
50	5.08	4.67	4.21

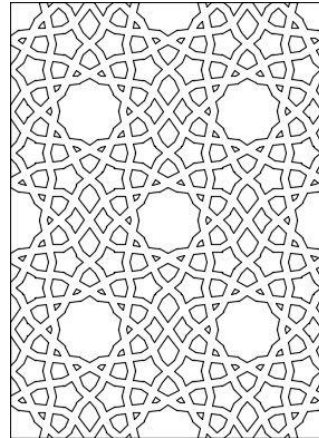
TABLE AP1.1.18. Saturation tables for tessellation ROS-I-6.10.10.



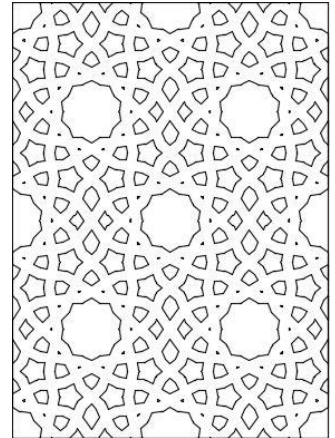
$\theta=48^\circ$ - rbd 1%



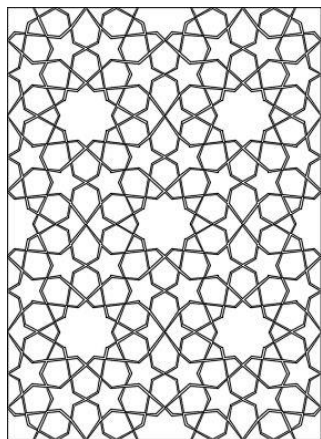
$\theta=48^\circ$ - rbd 3%



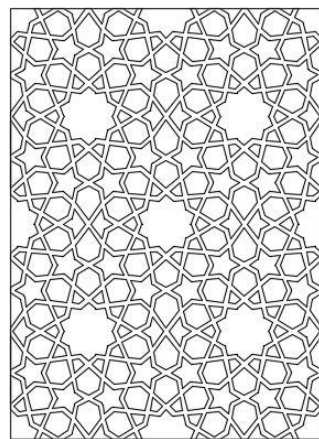
$\theta=48^\circ$ - rbd 5%



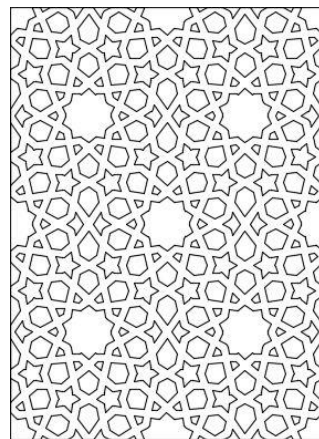
$\theta=48^\circ$ - rbd 7%



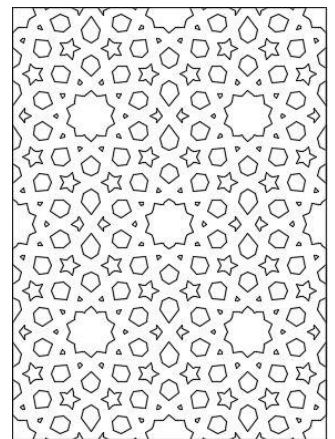
$\theta=60^\circ$ - rbd 1%



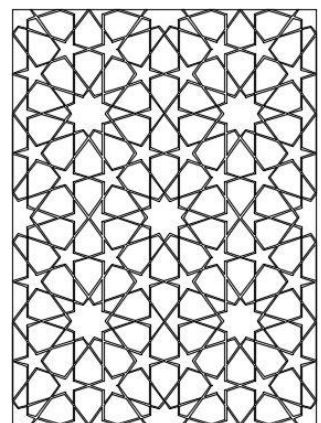
$\theta=60^\circ$ - rbd 3%



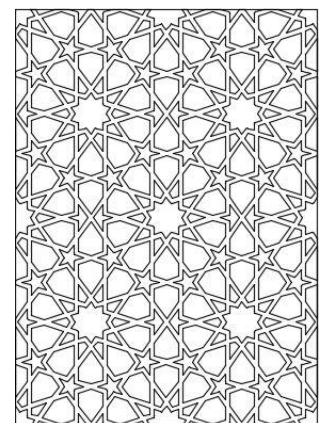
$\theta=60^\circ$ - rbd 5%



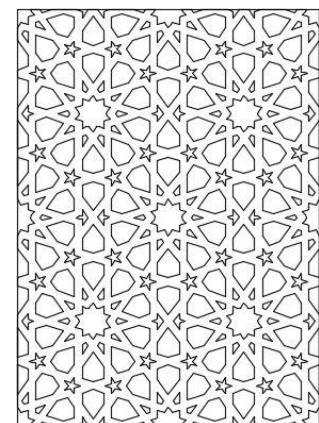
$\theta=60^\circ$ - rbd 7%



$\theta=72^\circ$ - rbd 1%



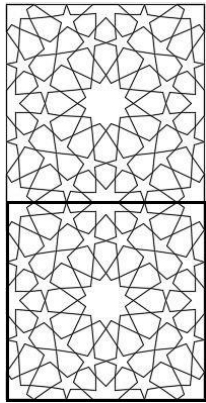
$\theta=72^\circ$ - rbd 3%



$\theta=72^\circ$ - rbd 5%

FIG AP1.1.18. Tessellation ROS-I-6.10.10. different relative beam depths applied to the parametric variations

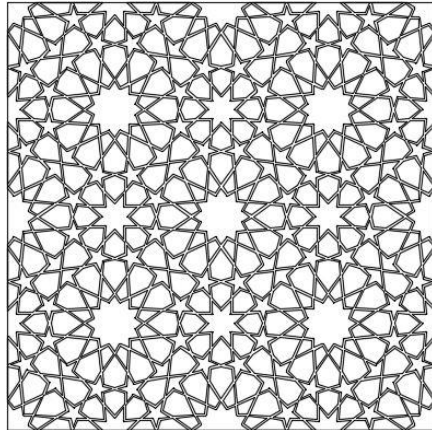
S) JAMEH MOSQUE



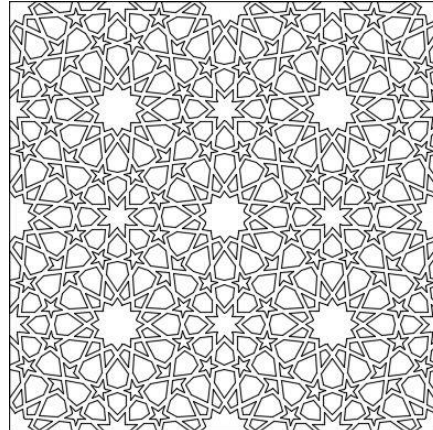
ROS-I-6.12.8.12 JAMEH MOSQUE				
rbd %	L = 20%	L = 35%	L = 50%	
0.5	10.94	11.20	11.50	
1.0	21.14	21.62	22.16	
1.5	30.61	31.25	31.97	
2.0	39.34	40.10	40.95	
2.5	47.33	48.16	49.08	
3.0	54.59	55.44	56.37	
3.5	61.10	X	X	
4.0	X	X	X	
4.5	X	X	X	

ROS-I-6.12.8.12 JAMEH MOSQUE				
Sat. %	L = 20%	L = 35%	L = 50%	
10	0.45	0.44	0.43	
15	0.70	0.68	0.66	
20	0.94	0.92	0.90	
25	1.20	1.18	1.14	
30	1.47	1.44	1.40	
35	1.75	1.71	1.67	
40	2.04	1.99	1.95	
45	2.35	2.30	2.25	
50	2.68	1.94	2.56	

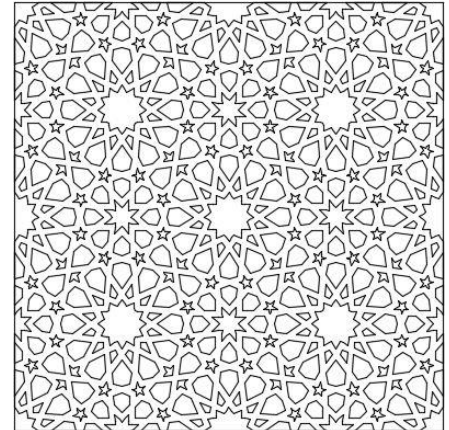
TABLE AP1.1.19. Saturation tables for tessellation ROS-I-6.12.8.12. $\theta=67.5^\circ$



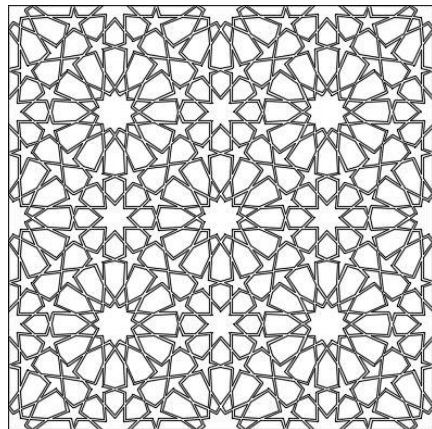
L=20% - rbd 1%



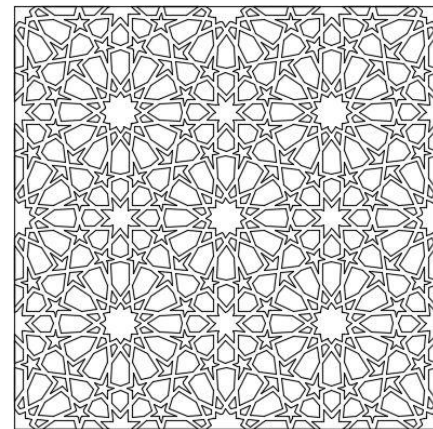
L=20% - rbd 2%



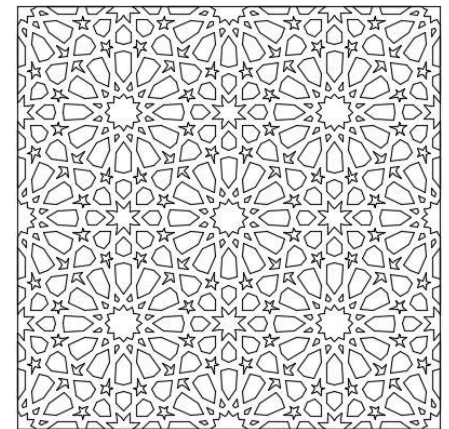
L=20% - rbd 3%



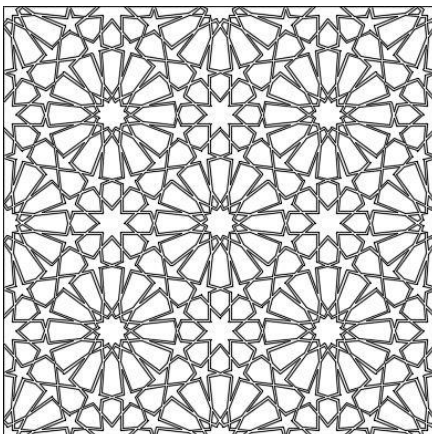
L=35% - rbd 1%



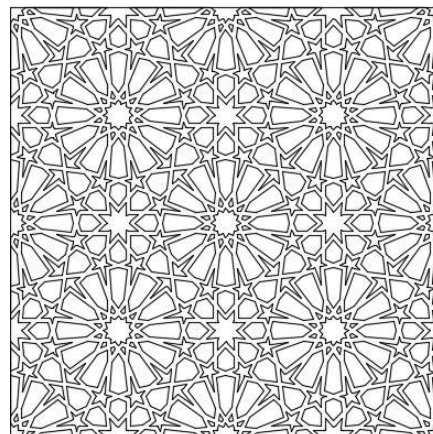
L=35% - rbd 2%



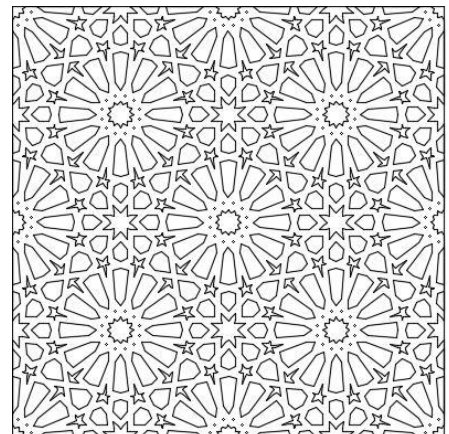
L=35% - rbd 3%



L=50% - rbd 1%



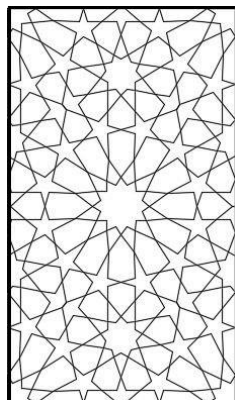
L=50% - rbd 2%



L=50% - rbd 3%

FIG AP1.1.19. Tessellation ROS-I-6.12.8.12. $\theta=67.5^\circ$ different relative beam depths applied to the parametric variations

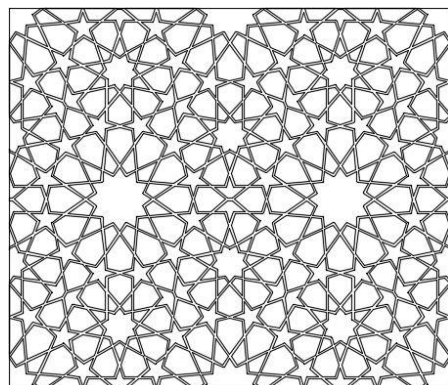
T) ALHAMBRA



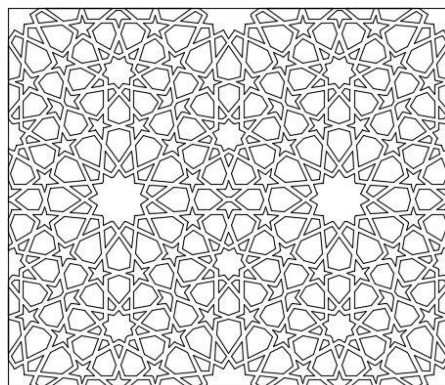
ROS-I-6.9.12.9 ALHAMBRA			
rbd %	L = 20%	L = 35%	L = 50%
0.5	10.56	10.75	10.95
1.0	20.43	20.78	21.15
1.5	29.61	30.08	30.60
2.0	38.09	38.67	39.30
2.5	45.89	46.54	47.24
3.0	53.00	53.68	54.43
3.5	59.41	60.11	X
4.0	65.14	65.81	X
4.5	X	X	X

ROS-I-6.9.12.9 ALHAMBRA			
Sat. %	L = 20%	L = 35%	L = 50%
10	0.47	0.46	0.45
15	0.72	0.71	0.70
20	0.98	0.96	0.94
25	1.25	1.23	1.20
30	1.52	1.50	1.47
35	1.82	1.79	1.75
40	2.12	2.08	2.04
45	2.44	2.40	2.36
50	2.79	2.74	2.69

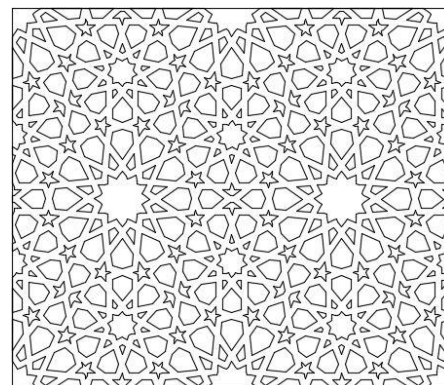
TABLE AP1.1.20. Saturation tables for tessellation ROS-I-6.9.12.9. $\theta=70^\circ$



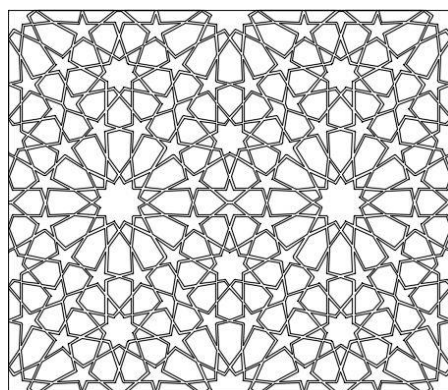
L=20% - rbd 1%



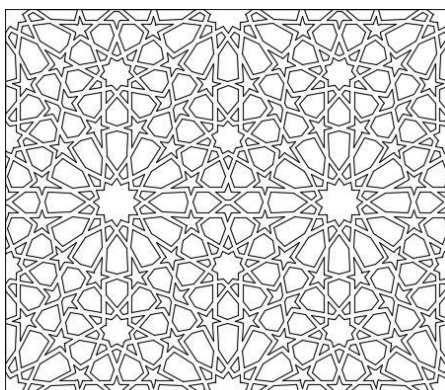
L=20% - rbd 2%



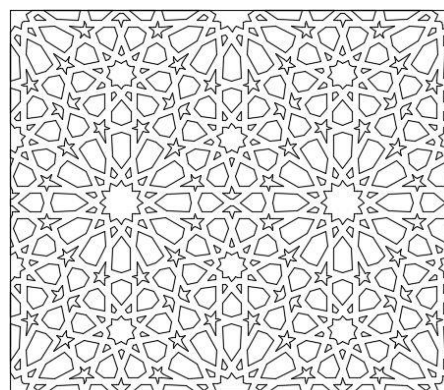
L=20% - rbd 3%



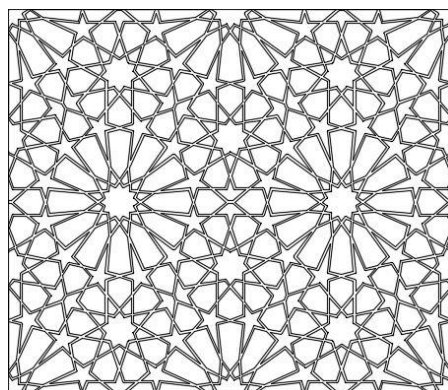
L=35% - rbd 1%



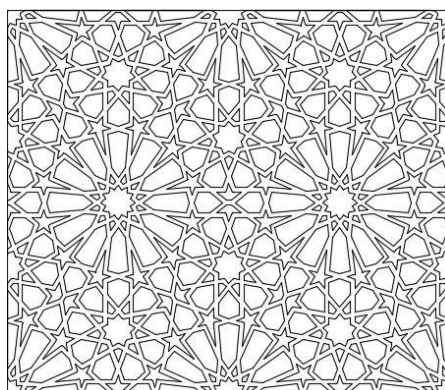
L=35% - rbd 2%



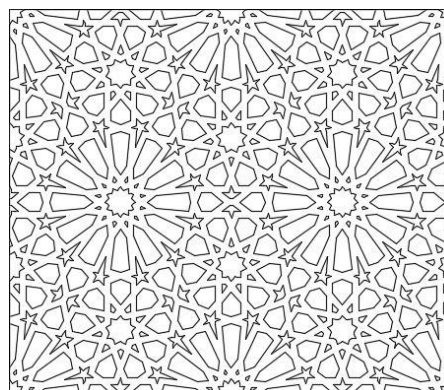
L=35% - rbd 3%



L=50% - rbd 1%



L=50% - rbd 2%



L=50% - rbd 3%

FIG AP1.1.20. Tessellation ROS-I-6.9.12.9. $\theta=70^\circ$. different relative beam depths applied to the parametric variations

2. FEM BEAM ELEMENTS

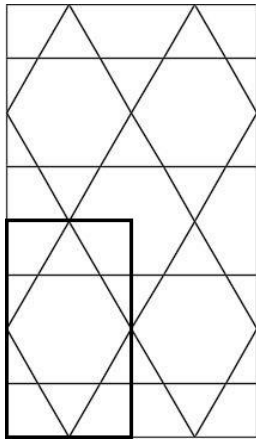
These homogenized equivalent properties are obtained using beam elements and refining the results to take into account the Representative Element Volume for an order of converge of 2 as per *Chapter 4.3. Representative Element Volume (REV)*. It corresponds to the first stage in the scheme described in Chapter 4.2. *Homogenization methodology*, named “- X - BEAM”.

The information included in each case from left to right is:

- Given name to the pattern and the tessellation and parameters to draw it with the Hankin method.
- Picture of the pattern displaying what is considered as its module. The module length in the x-direction (horizontally in the picture) is needed for the relative beam depth (rbd %) definition.
- Table of homogenized mechanical properties taking into account the Representative Element Volume
- Graphs with the evolution of the homogenized mechanical properties as the rbd increases.

The numerical results for 2x2 and 4x4 panels, leading to the obtained homogenized mechanical properties are collected in *Appendix II. Numerical results*.

A) YESLI MOSQUE. Tessellation 3.6.3.6.



A0		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
2	6.77	2.31%	2.31%	0.333	0.333	0.87%
4	13.24	4.63%	4.63%	0.332	0.332	1.74%
6	19.34	6.96%	6.96%	0.330	0.330	2.62%
8	25.15	9.31%	9.31%	0.328	0.328	3.51%
10	30.66	11.69%	11.69%	0.325	0.325	4.41%
12	35.82	14.10%	14.10%	0.322	0.322	5.33%
14	40.67	16.54%	16.54%	0.318	0.318	6.28%
16	45.20	19.02%	19.02%	0.314	0.314	7.24%
18	49.40	21.53%	21.53%	0.310	0.310	8.22%
20	53.29	24.07%	24.07%	0.305	0.305	9.22%

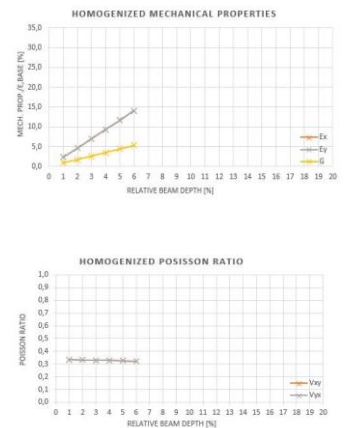
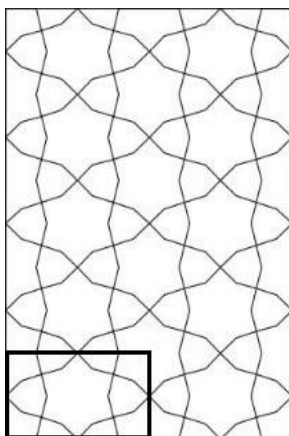


TABLE AP1.2.1 Pattern A0. Homogenized mechanical properties with beams FE

B) GREAT MOSQUE OF DAMASCUS. Tessellation 6.6.6.



B45		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	6.11	0.08%	0.08%	0.582	0.582	0.02%
2	12.01	0.54%	0.54%	0.546	0.546	0.17%
3	17.70	1.56%	1.56%	0.500	0.500	0.51%
4	23.18	3.06%	3.06%	0.455	0.455	1.04%
5	28.46	4.91%	4.91%	0.415	0.415	1.73%
6	33.53	6.97%	6.97%	0.382	0.382	2.51%
7	38.39	9.14%	9.14%	0.355	0.355	3.36%
8	43.04	11.36%	11.36%	0.334	0.334	4.25%
9	47.49	13.61%	13.61%	0.316	0.316	5.16%
10	51.72	15.86%	15.86%	0.302	0.302	6.08%

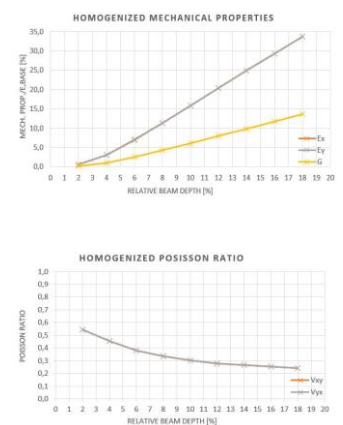
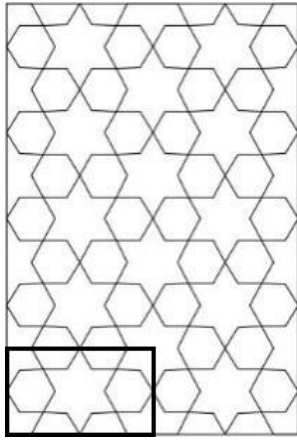


TABLE AP1.2.2. Pattern B45. Homogenized mechanical properties with beams FE



B60		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	6.81	0.02%	0.02%	0.496	0.496	0.01%
2	13.38	0.14%	0.14%	0.483	0.483	0.05%
3	19.70	0.45%	0.45%	0.464	0.464	0.15%
4	25.80	1.00%	1.00%	0.441	0.441	0.34%
5	31.64	1.79%	1.79%	0.415	0.415	0.63%
6	37.25	2.80%	2.80%	0.389	0.389	1.00%
7	42.62	4.00%	4.00%	0.364	0.364	1.46%
8	47.75	5.36%	5.36%	0.341	0.341	1.99%
9	52.63	6.84%	6.84%	0.320	0.320	2.58%
10	57.29	8.40%	8.40%	0.300	0.300	3.22%

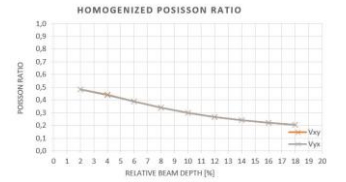
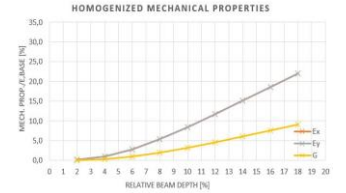
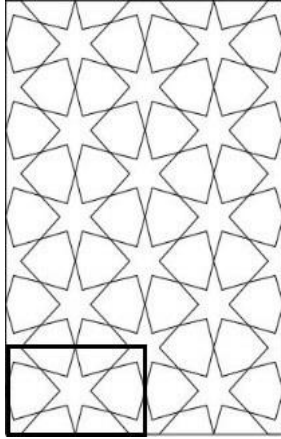


TABLE AP1.2.3. Pattern B60. Homogenized mechanical properties with beams FE



B75		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	8.28	0.01%	0.01%	0.356	0.356	0.00%
2	16.14	0.05%	0.05%	0.350	0.350	0.02%
3	23.59	0.17%	0.17%	0.340	0.340	0.06%
4	30.62	0.38%	0.38%	0.328	0.328	0.14%
5	37.23	0.71%	0.71%	0.313	0.313	0.27%
6	43.43	1.16%	1.16%	0.297	0.297	0.44%
7	49.21	1.73%	1.73%	0.280	0.280	0.67%
8	54.58	2.41%	2.41%	0.263	0.263	0.95%
9	59.53	3.19%	3.19%	0.246	0.246	1.28%
10	64.07	4.06%	4.06%	0.230	0.230	1.65%

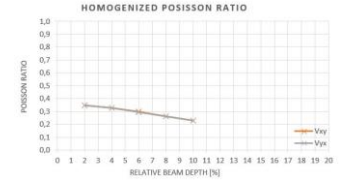
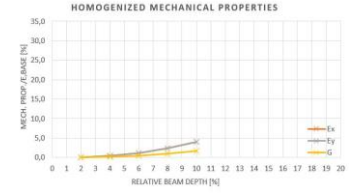
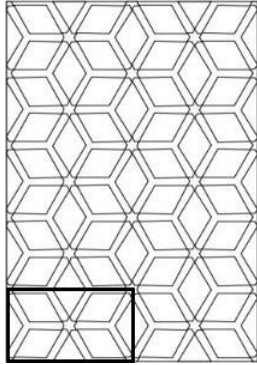


TABLE AP1.2.4. Pattern B75. Homogenized mechanical properties with beams FE

C) SABZ PUSHAN. Tessellation 6.6.6 $\theta = 60^\circ$



C20		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	10.81	0.04%	0.04%	0.516	0.516	0.01%
2	21.14	0.27%	0.27%	0.502	0.502	0.09%
3	30.99	0.83%	0.83%	0.480	0.480	0.28%
4	40.36	1.78%	1.78%	0.456	0.456	0.61%
5	49.25	3.08%	3.08%	0.430	0.430	1.07%
6	57.66	4.66%	4.66%	0.406	0.406	1.66%
7	65.59	6.47%	6.47%	0.383	0.383	2.34%
8	x	x	x	x	x	x

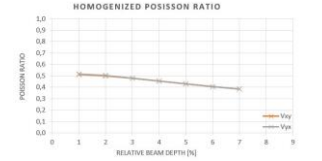
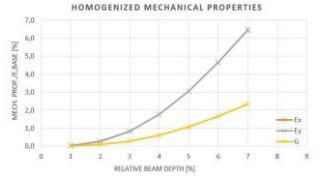
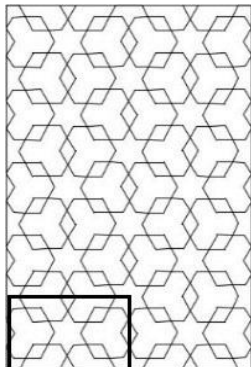


TABLE AP1.2.5. Pattern C20. Homogenized mechanical properties with beams FE



C35		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	8.77	0.02%	0.02%	0.744	0.744	0.01%
2	17.07	0.18%	0.18%	0.721	0.721	0.05%
3	24.88	0.57%	0.57%	0.687	0.687	0.17%
4	32.22	1.24%	1.24%	0.646	0.646	0.37%
5	39.07	2.20%	2.20%	0.601	0.601	0.68%
6	45.44	3.43%	3.43%	0.556	0.556	1.10%
7	51.34	4.89%	4.89%	0.513	0.513	1.61%
8	x	x	x	x	x	x

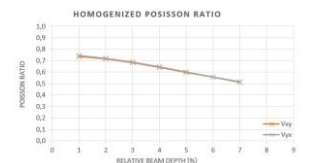
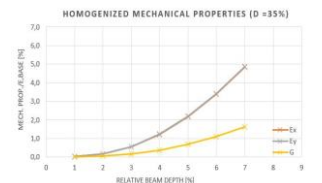
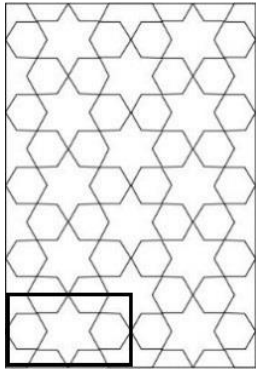


TABLE AP1.2.6. Pattern C35. Homogenized mechanical properties with beams FE



C50		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	6.81	0.02%	0.02%	0.496	0.496	0.01%
2	13.38	0.14%	0.14%	0.483	0.483	0.05%
3	19.70	0.45%	0.45%	0.464	0.464	0.15%
4	25.80	1.00%	1.00%	0.441	0.441	0.34%
5	31.64	1.79%	1.79%	0.415	0.415	0.63%
6	37.25	2.80%	2.80%	0.389	0.389	1.00%
7	42.62	4.00%	4.00%	0.364	0.364	1.46%
8	47.75	5.36%	5.36%	0.341	0.341	1.99%

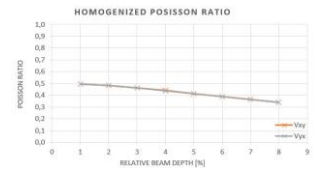
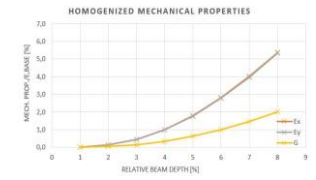
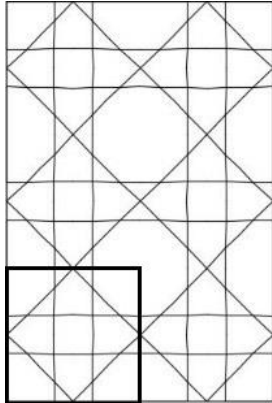


TABLE AP1.2.7. Pattern C50. Homogenized mechanical properties with beams FE

D) LAHORE FORT COMPLEX. Tessellation 4.8.8.



D45		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	6.66	2.52%	2.52%	0.261	0.261	0.71%
2	12.96	5.05%	5.05%	0.260	0.260	1.42%
3	18.93	7.59%	7.59%	0.259	0.259	2.14%
4	24.54	10.15%	10.15%	0.257	0.257	2.87%
5	29.81	12.72%	12.72%	0.255	0.255	3.61%
6	34.74	15.31%	15.31%	0.253	0.253	4.37%
7	39.32	17.92%	17.92%	0.250	0.250	5.14%
8	43.55	20.55%	20.55%	0.248	0.248	5.93%
9	47.43	23.19%	23.19%	0.245	0.245	6.74%

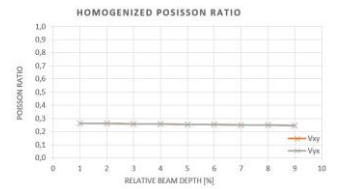
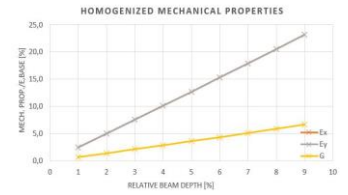
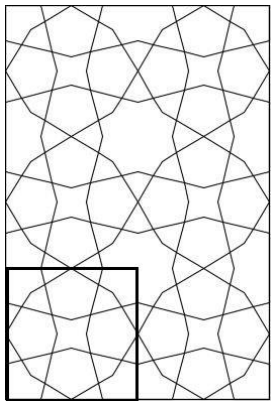


TABLE AP1.2.8. Pattern D45. Homogenized mechanical properties with beams FE



D60		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	6.92	0.28%	0.28%	0.286	0.286	0.02%
2	13.53	1.65%	1.65%	0.274	0.274	0.15%
3	19.84	3.82%	3.82%	0.265	0.265	0.46%
4	25.84	6.31%	6.31%	0.259	0.259	0.95%
5	31.54	8.89%	8.89%	0.254	0.254	1.58%
6	36.94	11.49%	11.49%	0.250	0.250	2.33%
7	42.03	14.09%	14.09%	0.245	0.245	3.16%
8	46.82	16.69%	16.69%	0.241	0.241	4.04%
9	51.30	19.29%	19.29%	0.237	0.237	4.96%

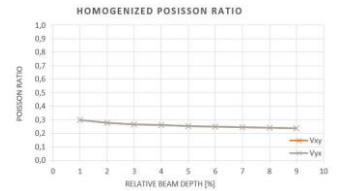
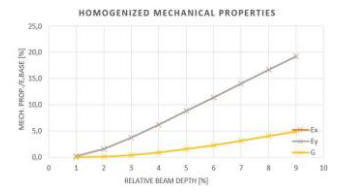
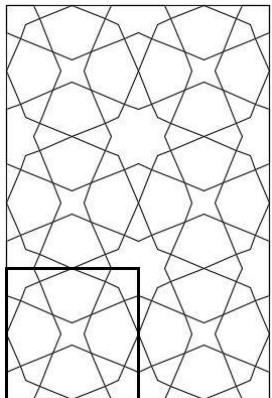


TABLE AP1.2.9. Pattern D60. Homogenized mechanical properties with beams FE



D67.5		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	7.23	0.18%	0.18%	0.191	0.191	0.01%
2	14.12	1.10%	1.10%	0.197	0.197	0.08%
3	20.69	2.76%	2.76%	0.207	0.207	0.25%
4	26.93	4.82%	4.82%	0.215	0.215	0.55%
5	32.83	7.05%	7.05%	0.221	0.221	0.96%
6	38.41	9.36%	9.36%	0.224	0.224	1.49%
7	43.66	11.69%	11.69%	0.225	0.225	2.12%
8	48.58	14.04%	14.04%	0.225	0.225	2.82%
9	53.17	16.41%	16.41%	0.223	0.223	3.58%

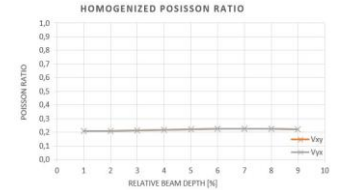
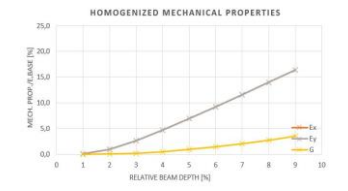
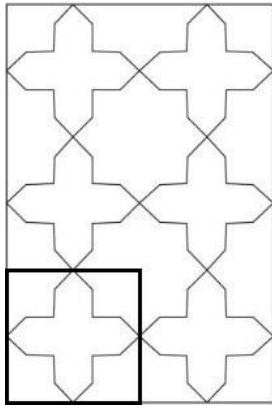


TABLE AP1.2.10. Pattern D67.5. Homogenized mechanical properties with beams FE

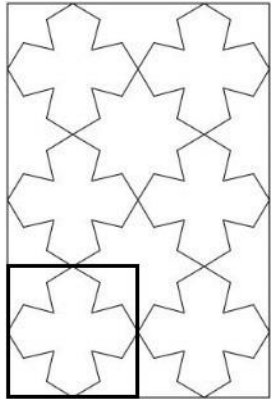
E) PALACE OF THE SHIRVANSHAHS Tessellation 4.8.8. with number of crossings = 0



E45		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
2	9.76	0.00%	0.00%	0.883	0.883	0.01%
3	14.51	0.01%	0.01%	0.880	0.880	0.04%
4	19.16	0.03%	0.03%	0.877	0.877	0.08%
5	23.73	0.06%	0.06%	0.872	0.872	0.16%
6	28.21	0.11%	0.11%	0.866	0.866	0.27%
7	32.60	0.17%	0.17%	0.860	0.860	0.41%
8	36.89	0.25%	0.25%	0.852	0.852	0.59%
9	41.10	0.35%	0.35%	0.844	0.844	0.80%
10	45.22	0.48%	0.48%	0.836	0.836	1.05%



TABLE AP1.2.11. Pattern E45. Homogenized mechanical properties with beams FE



E60		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
2	11.44	0.00%	0.00%	0.813	0.813	0.01%
3	17.05	0.01%	0.01%	0.810	0.810	0.03%
4	22.60	0.03%	0.03%	0.806	0.806	0.08%
5	28.08	0.06%	0.06%	0.800	0.800	0.15%
6	33.49	0.10%	0.10%	0.793	0.793	0.24%
7	38.83	0.16%	0.16%	0.785	0.785	0.36%
8	44.10	0.23%	0.23%	0.777	0.777	0.52%
9	49.30	0.33%	0.33%	0.767	0.767	0.69%
10	54.43	0.44%	0.44%	0.756	0.756	0.90%

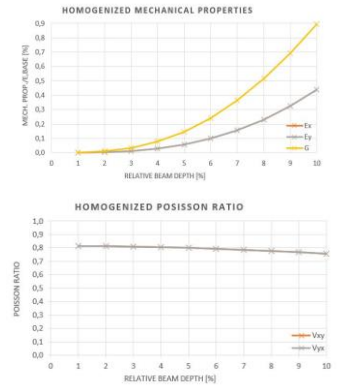
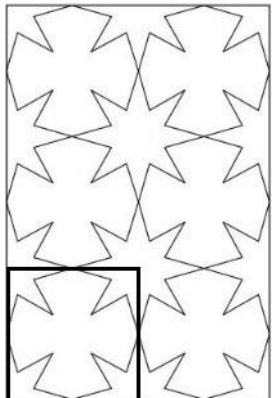


TABLE AP1.2.12. Pattern E60. Homogenized mechanical properties with beams FE



E75		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
2	15.03	0.00%	0.00%	0.632	0.632	0.00%
3	22.50	0.01%	0.01%	0.629	0.629	0.01%
4	29.95	0.02%	0.02%	0.624	0.624	0.03%
5	37.36	0.05%	0.05%	0.618	0.618	0.05%
6	44.66	0.08%	0.08%	0.611	0.611	0.09%
7	51.52	0.13%	0.13%	0.603	0.603	0.13%
8	57.91	0.19%	0.19%	0.594	0.594	0.19%
9	63.84	0.26%	0.26%	0.583	0.583	0.26%
10	69.30	0.36%	0.36%	0.572	0.572	0.35%

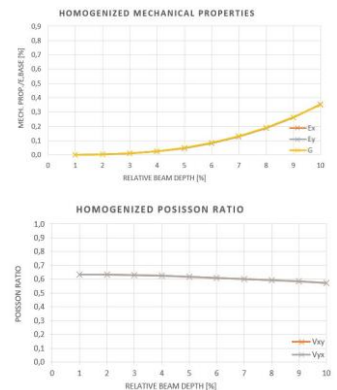
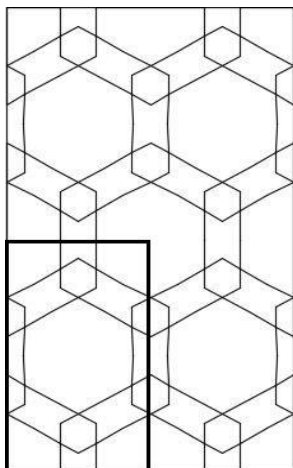


TABLE AP1.2.13. Pattern E75. Homogenized mechanical properties with beams FE

F) MUSTANSIRIYA MADRASA. Tessellation 6.6.6.



F30		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
2	9.68	0.03%	0.03%	0.973	0.973	0.01%
3	14.28	0.11%	0.11%	0.963	0.963	0.03%
4	18.72	0.26%	0.26%	0.949	0.949	0.07%
5	23.00	0.50%	0.50%	0.933	0.933	0.13%
6	27.12	0.84%	0.84%	0.914	0.914	0.22%
7	31.08	1.28%	1.28%	0.893	0.893	0.33%
8	34.88	1.84%	1.84%	0.870	0.870	0.49%
9	38.52	2.51%	2.51%	0.846	0.846	0.67%
10	42.00	3.29%	3.29%	0.822	0.822	0.89%
11	45.32	4.17%	4.17%	0.798	0.798	1.15%
12	48.48	5.14%	5.14%	0.774	0.774	1.44%

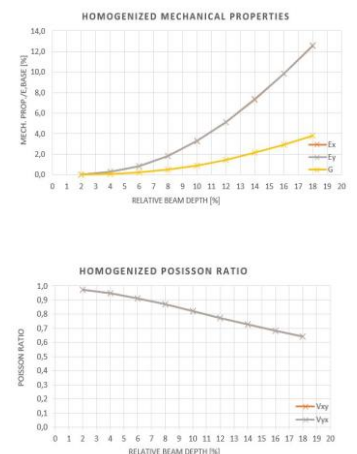
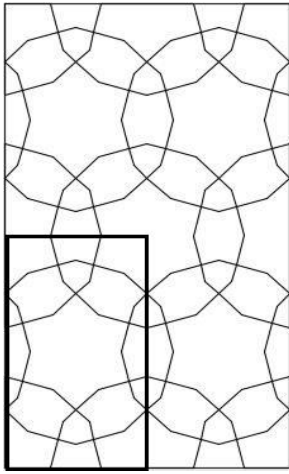


TABLE AP1.2.14. Pattern F30. Homogenized mechanical properties with beams FE



F45		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
2	9.52	0.04%	0.04%	0.929	0.929	0.01%
3	14.07	0.12%	0.12%	0.918	0.918	0.03%
4	18.49	0.28%	0.28%	0.904	0.904	0.07%
5	22.76	0.52%	0.52%	0.887	0.887	0.14%
6	26.90	0.87%	0.87%	0.868	0.868	0.23%
7	30.90	1.34%	1.34%	0.846	0.846	0.36%
8	34.76	1.92%	1.92%	0.823	0.823	0.52%
9	38.48	2.61%	2.61%	0.799	0.799	0.72%
10	42.06	3.42%	3.42%	0.774	0.774	0.95%
11	45.51	4.33%	4.33%	0.750	0.750	1.23%
12	48.81	5.34%	5.34%	0.725	0.725	1.53%

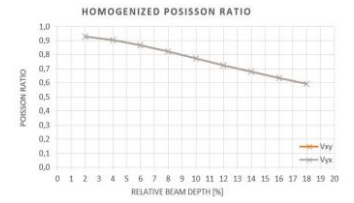
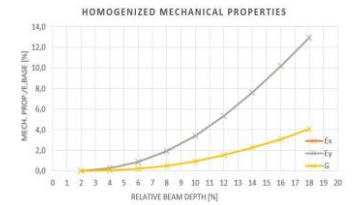
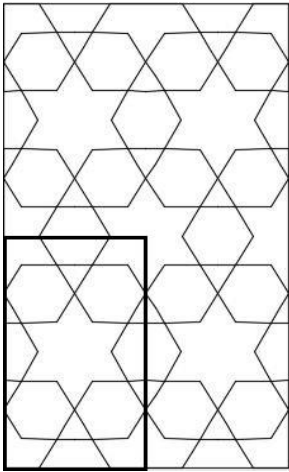


TABLE AP1.2.15. Pattern F45. Homogenized mechanical properties with beams FE



F60		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
2	10.07	0.03%	0.03%	0.736	0.736	0.01%
3	14.87	0.10%	0.10%	0.727	0.727	0.03%
4	19.51	0.23%	0.23%	0.715	0.715	0.07%
5	23.98	0.44%	0.44%	0.700	0.700	0.13%
6	28.30	0.74%	0.74%	0.683	0.683	0.22%
7	32.45	1.13%	1.13%	0.664	0.664	0.34%
8	36.45	1.62%	1.62%	0.644	0.644	0.49%
9	40.29	2.20%	2.20%	0.622	0.622	0.67%
10	43.96	2.88%	2.88%	0.601	0.601	0.89%
11	47.48	3.66%	3.66%	0.579	0.579	1.15%
12	50.84	4.51%	4.51%	0.557	0.557	1.44%

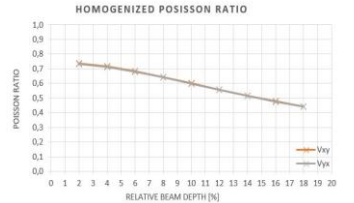
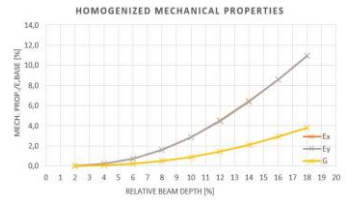
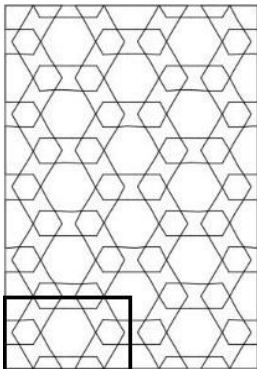


TABLE AP1.2.16. Pattern F60. Homogenized mechanical properties with beams FE

G) TOMB OF SALIM CHISHTI. Tessellation 6.6.6. D = 65%



G60		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	9.08	0.03%	0.03%	0.932	0.933	0.01%
2	17.69	0.21%	0.21%	0.912	0.913	0.05%
3	25.82	0.67%	0.67%	0.881	0.881	0.18%
4	33.47	1.49%	1.49%	0.842	0.842	0.40%
5	40.64	2.69%	2.69%	0.799	0.799	0.74%
6	47.34	4.25%	4.25%	0.754	0.754	1.20%
7	53.55	6.14%	6.14%	0.710	0.710	1.78%
8	59.29	8.30%	8.30%	0.668	0.668	2.48%

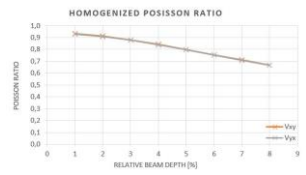
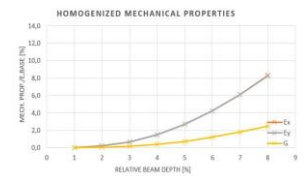
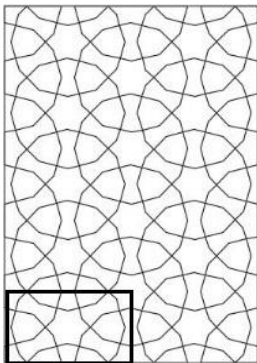


TABLE AP1.2.17. Pattern G60. Homogenized mechanical properties with beams FE



G75		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	9.45	0.05%	0.05%	0.892	0.893	0.01%
2	18.49	0.37%	0.37%	0.860	0.861	0.10%
3	27.11	1.15%	1.15%	0.814	0.815	0.31%
4	35.32	2.46%	2.47%	0.759	0.760	0.70%
5	43.10	4.29%	4.29%	0.703	0.703	1.25%
6	50.48	6.54%	6.54%	0.648	0.649	1.98%
7	57.45	9.11%	9.12%	0.598	0.599	2.84%
8	63.99	11.93%	11.93%	0.554	0.554	3.83%

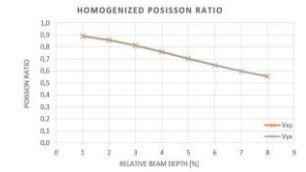
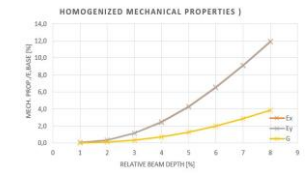
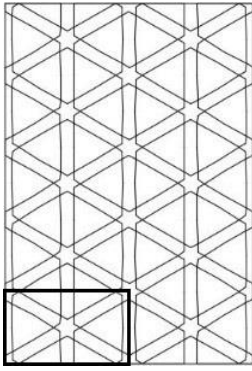


TABLE AP1.2.18. Pattern G75. Homogenized mechanical properties with beams FE



G90		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	10.54	0.25%	0.25%	0.712	0.715	0.07%
2	20.61	1.59%	1.60%	0.613	0.615	0.49%
3	30.19	4.01%	4.02%	0.514	0.516	1.33%
4	39.29	7.01%	7.03%	0.438	0.439	2.45%
5	47.91	10.25%	10.27%	0.384	0.384	3.72%
6	56.05	13.56%	13.58%	0.345	0.346	5.05%
7	x	x	x	x	x	x
8	x	x	x	x	x	x

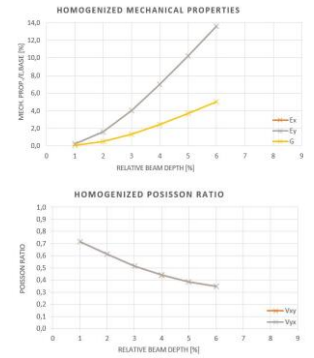
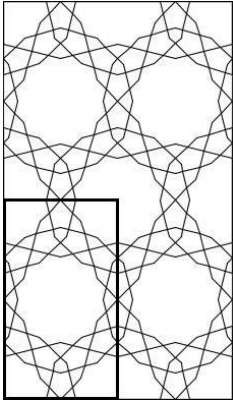


TABLE AP1.2.19. Pattern G90. Homogenized mechanical properties with beams FE

H) GENERALIFE. Tessellation 3.12.12.



H45		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	7.87	0.33%	0.33%	0.385	0.385	0.12%
2	15.21	1.76%	1.76%	0.387	0.387	0.63%
3	22.02	3.85%	3.85%	0.388	0.388	1.39%
4	28.31	6.14%	6.14%	0.386	0.386	2.21%
5	34.07	8.48%	8.48%	0.383	0.383	3.07%
6	39.30	10.84%	10.84%	0.379	0.379	3.93%
7	44.00	13.21%	13.21%	0.375	0.375	4.80%
8	48.17	15.60%	15.60%	0.370	0.370	5.69%
9	x	x	x	x	x	x

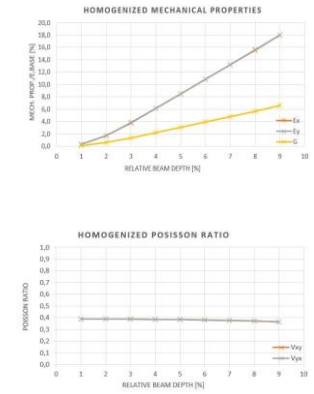
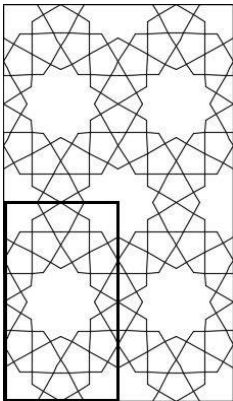


TABLE AP1.2.20. Pattern H45. Homogenized mechanical properties with beams FE



H60		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	8.67	0.13%	0.13%	0.104	0.104	0.06%
2	16.82	0.85%	0.85%	0.119	0.119	0.38%
3	24.46	2.25%	2.25%	0.137	0.137	0.99%
4	31.58	4.09%	4.09%	0.152	0.152	1.77%
5	38.18	6.16%	6.16%	0.163	0.163	2.65%
6	44.26	8.34%	8.34%	0.171	0.171	3.56%
7	49.83	10.58%	10.58%	0.176	0.176	4.50%
8	x	x	x	x	x	x
9	x	x	x	x	x	x

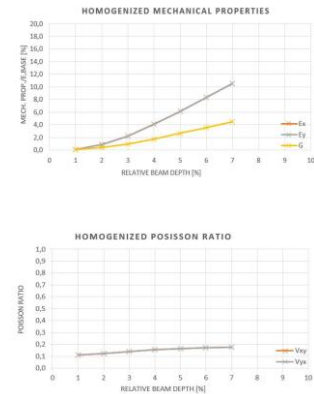
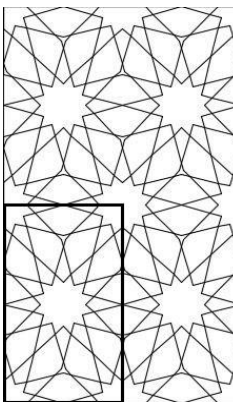


TABLE AP1.2.21. Pattern H60. Homogenized mechanical properties with beams FE



H75		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	10.39	0.09%	0.09%	-0.090	-0.090	0.05%
2	20.05	0.61%	0.61%	-0.059	-0.059	0.33%
3	28.97	1.63%	1.63%	-0.023	-0.023	0.83%
4	x	x	x	x	x	x
5	x	x	x	x	x	x
6	x	x	x	x	x	x
7	x	x	x	x	x	x
8	x	x	x	x	x	x
9	x	x	x	x	x	x

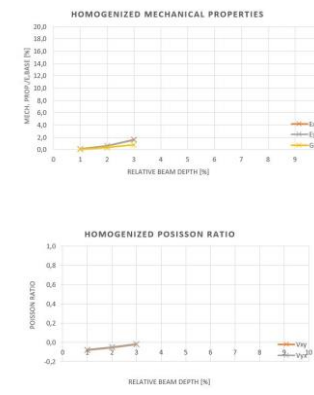
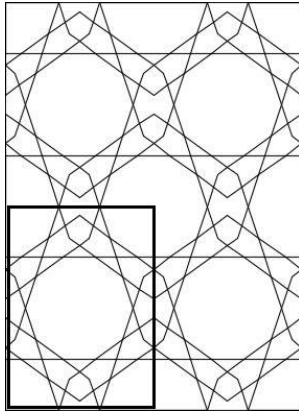


TABLE AP1.2.22. Pattern H75. Homogenized mechanical properties with beams FE

I) HASHT BEHESHT. Tessellation I-6.10.10.



I36		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	8.57	1.51%	0.67%	0.594	0.263	0.08%
2	16.41	3.23%	2.48%	0.578	0.443	0.43%
3	23.51	5.15%	4.55%	0.563	0.497	0.96%
4	29.87	7.17%	6.69%	0.550	0.513	1.60%
5	35.49	9.27%	8.87%	0.538	0.515	2.32%
6	40.37	11.44%	11.10%	0.528	0.512	3.12%
7	44.51	13.69%	13.39%	0.518	0.507	3.98%
8	x	x	x	x	x	x
9	x	x	x	x	x	x

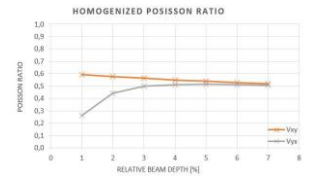
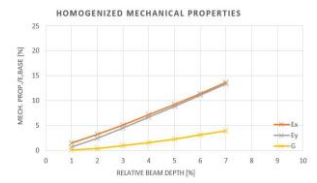
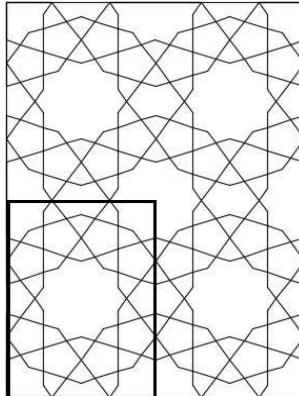


TABLE AP1.2.23. Pattern I36. Homogenized mechanical properties with beams FE



I54		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	8.89	0.34%	0.40%	0.263	0.312	0.14%
2	17.23	1.89%	2.14%	0.279	0.317	0.78%
3	25.03	4.27%	4.68%	0.290	0.317	1.75%
4	32.27	6.98%	7.46%	0.295	0.315	2.85%
5	38.96	9.80%	10.29%	0.296	0.311	3.98%
6	45.10	12.66%	13.13%	0.295	0.306	5.13%
7	50.69	15.55%	15.97%	0.293	0.301	6.29%
8	55.74	18.45%	18.82%	0.290	0.296	7.48%
9	60.23	21.38%	21.69%	0.287	0.291	8.68%

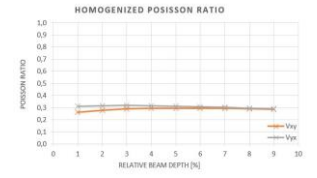
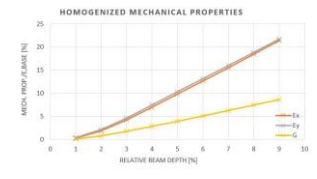
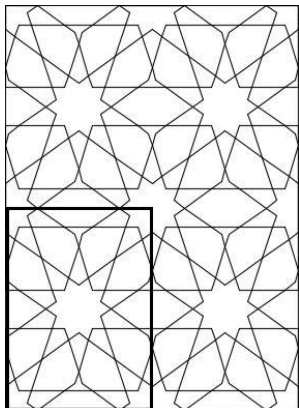


TABLE AP1.2.24. Pattern I54. Homogenized mechanical properties with beams FE



I72		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	10.18	0.22%	0.17%	-0.041	-0.031	0.09%
2	19.65	1.35%	1.04%	0.020	0.015	0.56%
3	28.43	3.28%	2.59%	0.073	0.058	1.33%
4	36.50	5.61%	4.50%	0.110	0.088	2.25%
5	43.88	8.10%	6.58%	0.132	0.108	3.24%
6	x	x	x	x	x	x
7	x	x	x	x	x	x
8	x	x	x	x	x	x
9	x	x	x	x	x	x

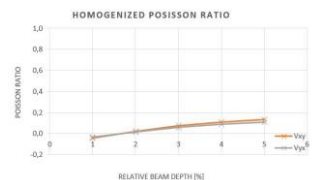
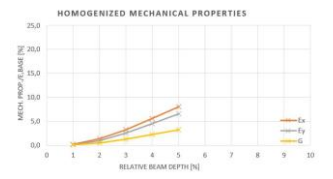
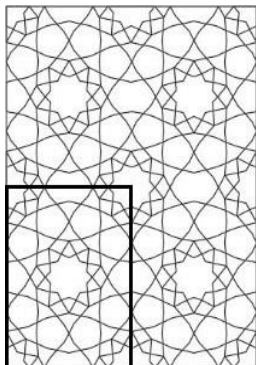


TABLE AP1.2.25. Pattern I72. Homogenized mechanical properties with beams FE

J) MODARI-KHAN MADRASH. Tessellation ROS-I-6.10.10. $\theta_1 = 45^\circ$, type Star



J30		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	13.60	1.12%	1.21%	0.557	0.603	0.34%
2	25.97	4.96%	5.05%	0.434	0.442	1.67%
3	37.10	9.75%	9.58%	0.368	0.362	3.45%
4	47.00	14.70%	14.19%	0.333	0.321	5.34%
5	55.66	19.69%	18.82%	0.311	0.298	7.27%
6	63.09	24.69%	23.49%	0.296	0.281	9.23%
7	x	x	x	x	x	x
8	x	x	x	x	x	x

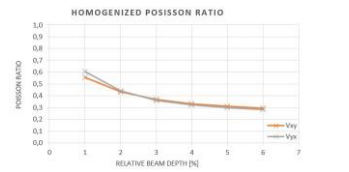
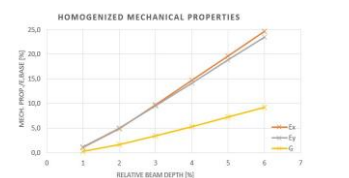
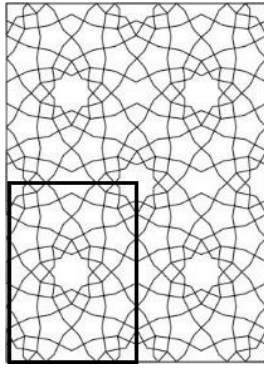


TABLE AP1.2.26. Pattern J30. Homogenized mechanical properties with beams FE



J45		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	13.49	0.37%	0.50%	0.660	0.889	0.20%
2	25.86	2.36%	2.90%	0.579	0.713	1.13%
3	37.09	5.94%	6.81%	0.499	0.572	2.69%
4	47.19	10.43%	11.40%	0.436	0.476	4.56%
5	56.16	15.33%	16.24%	0.389	0.412	6.59%
6	64.00	20.39%	21.17%	0.354	0.368	8.68%
7	x	x	x	x	x	x
8	x	x	x	x	x	x

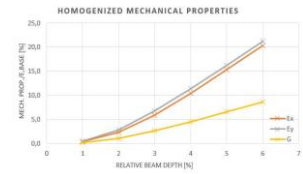
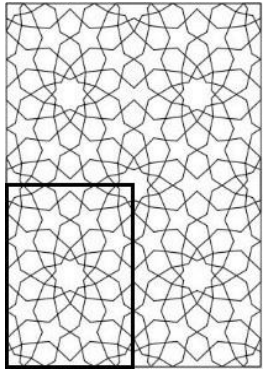


TABLE AP1.2.27. Pattern J45. Homogenized mechanical properties with beams FE



J60		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	13.97	0.14%	0.18%	0.596	0.786	0.09%
2	26.73	0.99%	1.25%	0.563	0.712	0.56%
3	38.29	2.84%	3.43%	0.520	0.628	1.48%
4	48.64	5.59%	6.50%	0.474	0.551	2.77%
5	57.79	8.99%	10.15%	0.432	0.487	4.32%
6	x	x	x	x	x	x
7	x	x	x	x	x	x
8	x	x	x	x	x	x

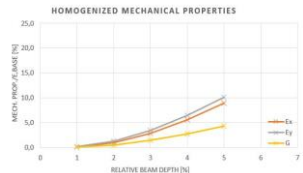
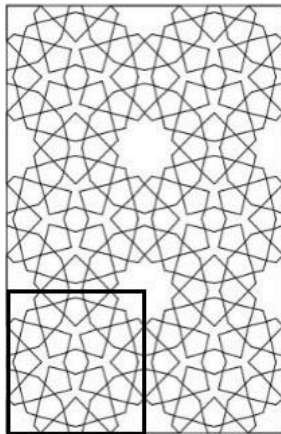


TABLE AP1.2.28. Pattern J60. Homogenized mechanical properties with beams FE

K) COMPLEX OF SULTAN BAYEZID II. Tessellation ROS-3.4.3.12.3.12.12. type Bayezid



K60		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
0.5	6.99	0.03%	0.03%	0.669	0.669	0.01%
1.0	13.68	0.20%	0.20%	0.639	0.639	0.05%
1.5	20.08	0.58%	0.58%	0.603	0.603	0.15%
2.0	26.19	1.18%	1.18%	0.568	0.568	0.33%
2.5	32.01	1.99%	1.99%	0.537	0.537	0.60%
3.0	37.54	2.96%	2.96%	0.510	0.510	0.96%
3.5	42.77	4.09%	4.09%	0.485	0.485	1.40%
4.0	47.72	5.34%	5.34%	0.463	0.463	1.91%
4.5	52.37	6.70%	6.70%	0.443	0.443	2.47%
5.0	56.73	8.15%	8.15%	0.424	0.424	3.09%

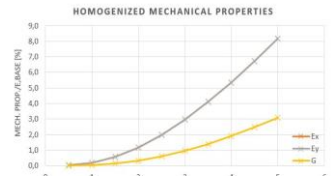
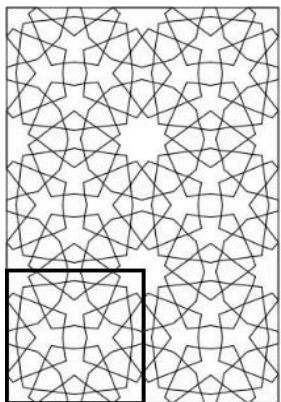


TABLE AP1.2.29. Pattern K60. Homogenized mechanical properties with beams FE



K67.5		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
0.5	6.89	0.03%	0.03%	0.619	0.619	0.01%
1.0	13.48	0.20%	0.20%	0.598	0.598	0.04%
1.5	19.78	0.60%	0.60%	0.572	0.572	0.14%
2.0	25.78	1.24%	1.24%	0.545	0.545	0.31%
2.5	31.48	2.08%	2.08%	0.519	0.519	0.56%
3.0	36.88	3.11%	3.11%	0.494	0.494	0.90%
3.5	41.99	4.29%	4.29%	0.471	0.471	1.31%
4.0	46.79	5.59%	5.59%	0.449	0.449	1.79%
4.5	51.30	6.99%	6.99%	0.429	0.429	2.33%

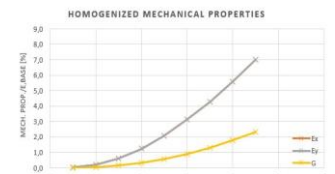
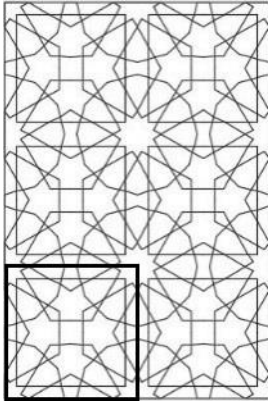


TABLE AP1.2.30. Pattern K67.5. Homogenized mechanical properties with beams FE



K75		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
0.5	6.99	0.03%	0.03%	0.496	0.496	0.01%
1.0	13.64	0.24%	0.24%	0.491	0.491	0.04%
1.5	19.96	0.71%	0.71%	0.482	0.482	0.13%
2.0	25.95	1.43%	1.43%	0.469	0.469	0.29%
2.5	31.61	2.36%	2.36%	0.454	0.454	0.52%
3.0	36.93	3.46%	3.46%	0.437	0.437	0.83%
3.5	41.91	4.70%	4.70%	0.419	0.419	1.22%
4.0	x	x	x	x	x	x
4.5	x	x	x	x	x	x

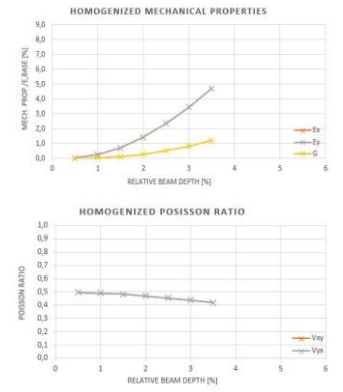
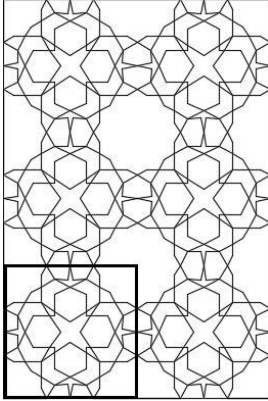


TABLE AP1.2.31. Pattern K75. Homogenized mechanical properties with beams FE

L) BEN YUSUF MADRASA. Tessellation ROS-3.4.3.12.3.12.12. $\theta = 75^\circ$ type Arrow



L45		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
0.5	5.91	0.01%	0.01%	0.763	0.763	0.01%
1.0	11.54	0.10%	0.10%	0.749	0.749	0.04%
1.5	16.91	0.33%	0.33%	0.727	0.727	0.14%
2.0	22.00	0.73%	0.73%	0.701	0.701	0.32%
2.5	26.81	1.30%	1.30%	0.673	0.673	0.57%
3.0	31.36	2.04%	2.04%	0.645	0.645	0.89%
3.5	35.63	2.93%	2.93%	0.617	0.617	1.28%
4.0	39.63	3.96%	3.96%	0.590	0.590	1.73%
4.5	x	x	x	x	x	x

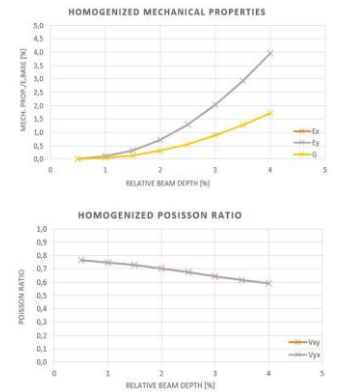
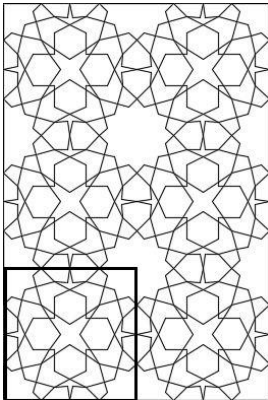


TABLE AP1.2.32. Pattern L45. Homogenized mechanical properties with beams FE



L60		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
0.5	6.19	0.01%	0.01%	0.498	0.498	0.01%
1.0	12.12	0.11%	0.11%	0.490	0.490	0.04%
1.5	17.77	0.35%	0.35%	0.477	0.477	0.14%
2.0	23.15	0.77%	0.77%	0.462	0.462	0.31%
2.5	28.27	1.35%	1.35%	0.446	0.446	0.56%
3.0	33.11	2.10%	2.10%	0.429	0.429	0.88%
3.5	37.68	2.99%	2.99%	0.413	0.413	1.27%
4.0	41.99	3.98%	3.98%	0.397	0.397	1.72%
4.5	x	x	x	x	x	x

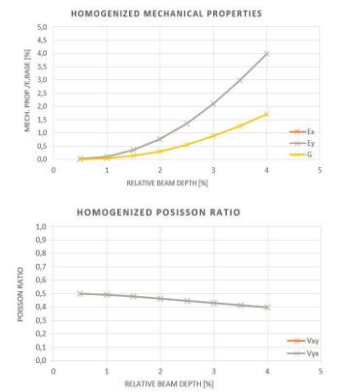
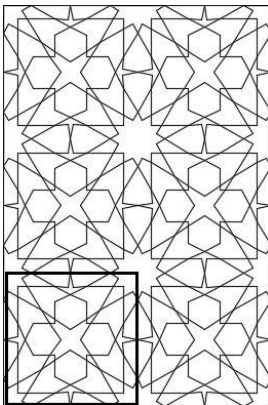


TABLE AP1.2.33. Pattern L60. Homogenized mechanical properties with beams FE



L75		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
0.5	6.79	0.02%	0.02%	0.185	0.185	0.00%
1.0	13.28	0.12%	0.12%	0.193	0.193	0.04%
1.5	19.46	0.37%	0.37%	0.203	0.203	0.12%
2.0	25.33	0.79%	0.79%	0.213	0.213	0.27%
2.5	30.91	1.36%	1.36%	0.221	0.221	0.49%
3.0	36.17	2.06%	2.06%	0.226	0.226	0.78%
3.5	41.14	2.87%	2.87%	0.229	0.229	1.13%
4.0	45.79	3.77%	3.77%	0.229	0.229	1.53%
4.5	x	x	x	x	x	x

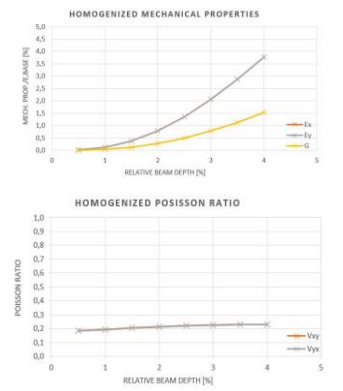
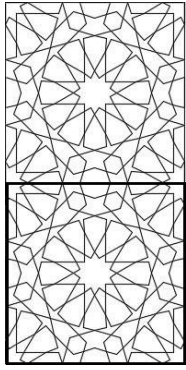


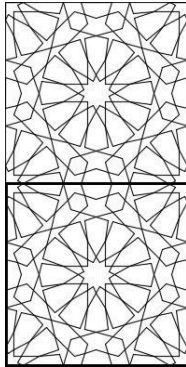
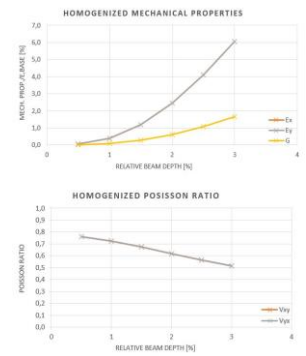
TABLE AP1.2.34. Pattern L75. Homogenized mechanical properties with beams FE

M) AL-NASIR MUHAMMAD'S MINBAR. Tessellation ROS-I-6.12.8.12. $\theta = 75^\circ$, type Arrow



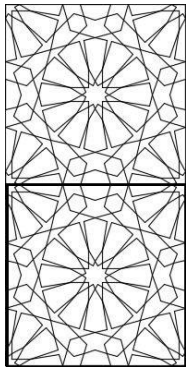
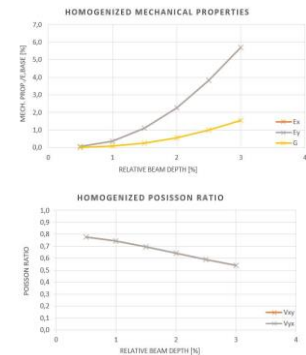
M20		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
0.5	11.13	0.05%	0.05%	0.762	0.762	0.01%
1.0	21.42	0.40%	0.40%	0.724	0.724	0.09%
1.5	30.88	1.19%	1.19%	0.673	0.673	0.28%
2.0	39.51	2.44%	2.44%	0.618	0.618	0.61%
2.5	47.30	4.09%	4.09%	0.564	0.564	1.06%
3.0	54.25	6.04%	6.04%	0.516	0.516	1.64%
3.5	x	x	x	x	x	x
4.0	x	x	x	x	x	x

TABLE AP1.2.35. Pattern M20. Homogenized mechanical properties with beams FE



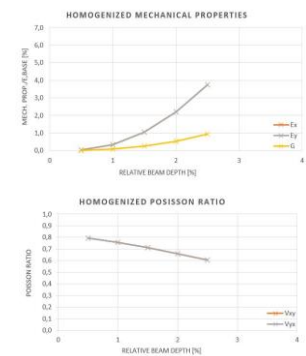
M35		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
0.5	11.38	0.05%	0.05%	0.778	0.778	0.01%
1.0	21.82	0.36%	0.36%	0.743	0.743	0.08%
1.5	31.32	1.10%	1.10%	0.694	0.694	0.26%
2.0	39.89	2.27%	2.27%	0.641	0.641	0.56%
2.5	47.52	3.83%	3.83%	0.588	0.588	0.99%
3.0	54.23	5.70%	5.70%	0.541	0.541	1.53%
3.5	x	x	x	x	x	x
4.0	x	x	x	x	x	x

TABLE AP1.2.36. Pattern M35. Homogenized mechanical properties with beams FE

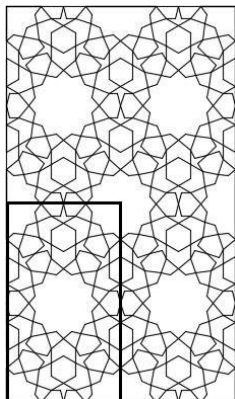


M50		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
0.5	11.63	0.05%	0.05%	0.793	0.793	0.01%
1.0	22.22	0.34%	0.34%	0.759	0.759	0.08%
1.5	31.78	1.05%	1.05%	0.712	0.712	0.24%
2.0	40.29	2.19%	2.19%	0.659	0.659	0.53%
2.5	47.77	3.73%	3.73%	0.607	0.607	0.95%
3.0	x	x	x	x	x	x
3.5	x	x	x	x	x	x
4.0	x	x	x	x	x	x

TABLE AP1.2.37. Pattern M50. Homogenized mechanical properties with beams FE

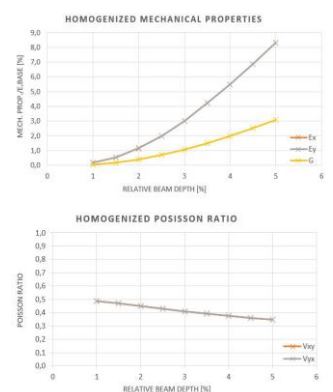


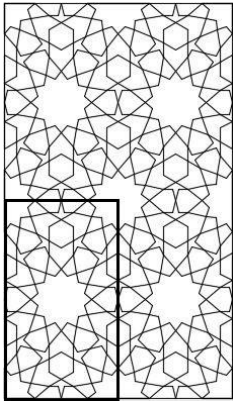
N) MOSQUE OF AL-NASIR MUHAMMAD. Tessellation ROS-3.12.12. $\theta = 75^\circ$ type Arrow



N55		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1.0	11.71	0.18%	0.18%	0.486	0.486	0.06%
1.5	17.19	0.55%	0.55%	0.469	0.469	0.19%
2.0	22.41	1.16%	1.16%	0.450	0.450	0.40%
2.5	27.39	2.00%	2.00%	0.430	0.430	0.70%
3.0	32.12	3.02%	3.02%	0.411	0.411	1.07%
3.5	36.59	4.20%	4.20%	0.393	0.393	1.51%
4.0	40.81	5.49%	5.49%	0.376	0.376	1.99%
4.5	44.79	6.86%	6.86%	0.361	0.361	2.52%
5.0	48.51	8.31%	8.31%	0.347	0.347	3.08%

TABLE AP1.2.38. Pattern N55. Homogenized mechanical properties with beams FE





N65		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1.0	12.35	0.14%	0.14%	0.302	0.302	0.05%
1.5	18.14	0.45%	0.45%	0.298	0.298	0.17%
2.0	23.67	0.95%	0.95%	0.292	0.292	0.37%
2.5	28.94	1.66%	1.66%	0.285	0.285	0.65%
3.0	33.95	2.54%	2.54%	0.278	0.278	0.99%
3.5	38.70	3.55%	3.55%	0.270	0.270	1.40%
4.0	43.19	4.68%	4.68%	0.262	0.262	1.85%
4.5	47.42	5.89%	5.89%	0.254	0.254	2.35%
5.0	51.39	7.17%	7.17%	0.247	0.247	2.87%

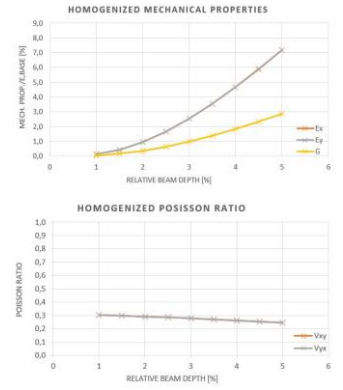
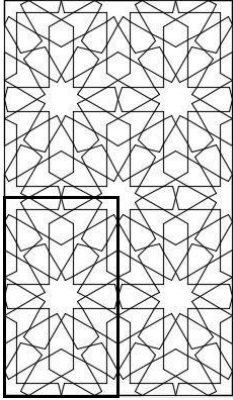


TABLE AP1.2.39. Pattern N65. Homogenized mechanical properties with beams FE



N75		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1.0	13.38	0.13%	0.13%	0.201	0.201	0.05%
1.5	19.51	0.40%	0.40%	0.206	0.206	0.17%
2.0	25.59	0.85%	0.85%	0.210	0.210	0.35%
2.5	31.25	1.48%	1.48%	0.212	0.212	0.61%
3.0	36.62	2.25%	2.25%	0.212	0.212	0.93%
3.5	41.60	3.14%	3.14%	0.210	0.210	1.30%
4.0	46.57	4.13%	4.13%	0.207	0.207	1.71%
4.5	50.97	5.19%	5.19%	0.202	0.202	2.16%
5.0	55.17	6.31%	6.31%	0.197	0.197	2.64%

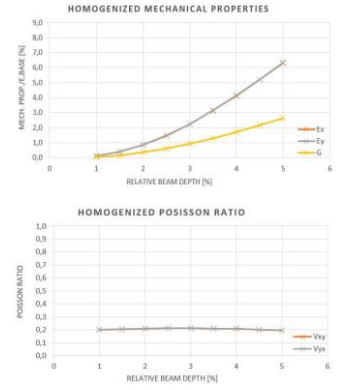
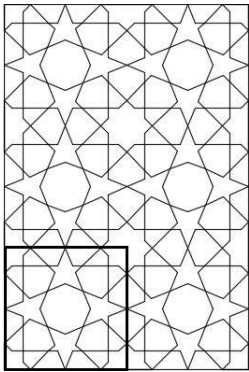


TABLE AP1.2.40. Pattern N75. Homogenized mechanical properties with beams FE

O) GREAT MOSQUE OF HERAT. Tessellation ROS-4.8.8. $\theta = 70^\circ$



O15		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	9.59	0.06%	0.06%	0.478	0.478	0.02%
2	18.63	0.47%	0.47%	0.448	0.448	0.11%
3	27.02	1.41%	1.41%	0.409	0.409	0.35%
4	35.04	2.87%	2.87%	0.367	0.367	0.74%
5	42.05	4.76%	4.76%	0.328	0.328	1.28%
6	49.23	6.95%	6.95%	0.294	0.294	1.95%
7	55.49	9.37%	9.37%	0.266	0.266	2.71%
8	61.19	11.92%	11.92%	0.242	0.242	3.56%

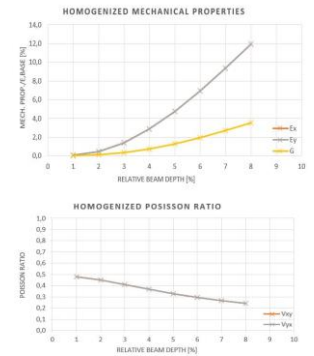
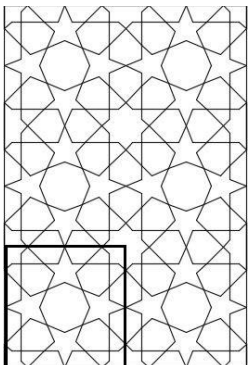


TABLE AP1.2.41. Pattern O15. Homogenized mechanical properties with beams FE



O22.5		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	9.54	0.05%	0.05%	0.444	0.444	0.01%
2	18.52	0.40%	0.40%	0.430	0.430	0.07%
3	26.95	1.21%	1.21%	0.409	0.409	0.22%
4	34.82	2.50%	2.50%	0.383	0.383	0.48%
5	42.14	4.20%	4.20%	0.356	0.356	0.87%
6	48.90	6.24%	6.24%	0.328	0.328	1.37%
7	55.11	8.52%	8.52%	0.303	0.303	1.98%
8	60.76	10.97%	10.97%	0.279	0.279	2.69%

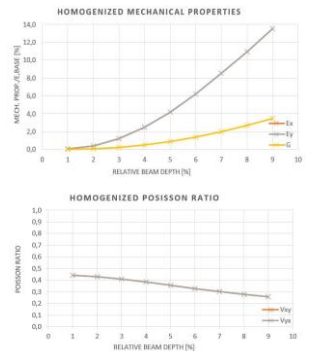
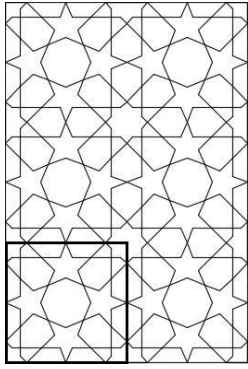


TABLE AP1.2.42. Pattern O22.5. Homogenized mechanical properties with beams FE



O30		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	9.48	0.06%	0.06%	0.415	0.415	0.01%
2	18.41	0.41%	0.41%	0.409	0.409	0.05%
3	26.79	1.21%	1.21%	0.399	0.399	0.16%
4	34.61	2.47%	2.47%	0.384	0.384	0.37%
5	41.87	4.11%	4.11%	0.366	0.366	0.68%
6	48.58	6.07%	6.07%	0.346	0.346	1.09%
7	54.73	8.27%	8.27%	0.325	0.325	1.60%
8	60.33	10.64%	10.64%	0.304	0.304	2.21%

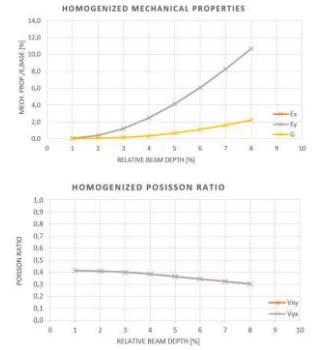
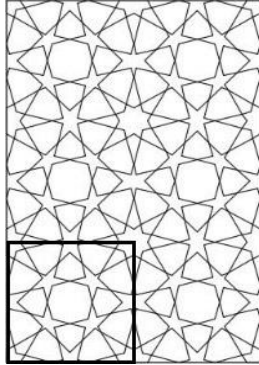


TABLE AP1.2.43. Pattern O30. Homogenized mechanical properties with beams FE

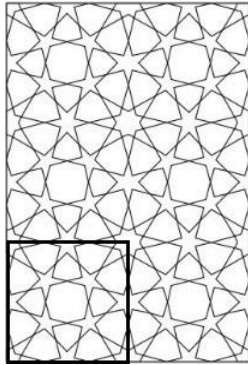
P) MOSQUE OF AL-SALIH TALA'I. Tessellation ROS-3.4.3.8.3.8.8. $\theta = 75^\circ$ type Star



P15		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1.0	11.97	0.04%	0.04%	0.481	0.481	0.01%
2.0	22.99	0.29%	0.29%	0.462	0.462	0.11%
3.0	33.15	0.90%	0.90%	0.434	0.434	0.33%
4.0	42.15	1.89%	1.89%	0.402	0.402	0.71%
5.0	50.32	3.25%	3.25%	0.369	0.369	1.25%
6.0	57.58	4.91%	4.91%	0.338	0.338	1.93%
7.0	x	x	x	x	x	x
8.0	x	x	x	x	x	x



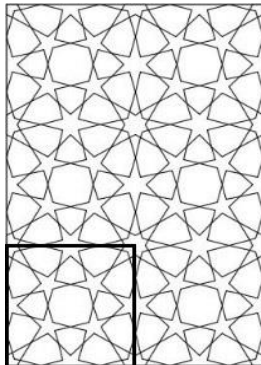
TABLE AP1.2.44. Pattern P15. Homogenized mechanical properties with beams FE



P25		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1.0	11.92	0.04%	0.04%	0.462	0.462	0.01%
2.0	22.88	0.27%	0.27%	0.451	0.451	0.10%
3.0	32.89	0.82%	0.82%	0.433	0.433	0.32%
4.0	41.94	1.75%	1.75%	0.410	0.410	0.69%
5.0	50.02	3.02%	3.02%	0.384	0.384	1.22%
6.0	57.15	4.60%	4.60%	0.357	0.357	1.88%
7.0	x	x	x	x	x	x
8.0	x	x	x	x	x	x



TABLE AP1.2.45. Pattern P25. Homogenized mechanical properties with beams FE



P35		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1.0	11.87	0.03%	0.03%	0.497	0.497	0.01%
2.0	22.78	0.25%	0.25%	0.488	0.488	0.10%
3.0	32.73	0.76%	0.76%	0.473	0.473	0.32%
4.0	41.72	1.62%	1.62%	0.453	0.453	0.69%
5.0	49.76	2.81%	2.81%	0.429	0.429	1.21%
6.0	x	x	x	x	x	x
7.0	x	x	x	x	x	x
8.0	x	x	x	x	x	x

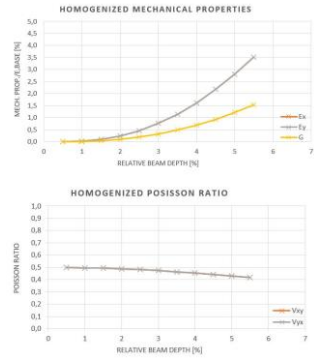
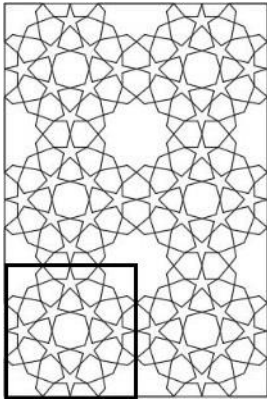


TABLE AP1.2.46. Pattern P35. Homogenized mechanical properties with beams FE

Q) MOSQUE OF IBN TULUN. Tessellation ROS-3.4.3.12.3.12.12. $\theta_1 = 75^\circ$



Q55		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
0.5	6.43	0.01%	0.01%	0.352	0.352	0.01%
1.0	12.57	0.11%	0.11%	0.352	0.352	0.05%
1.5	18.41	0.36%	0.36%	0.351	0.351	0.14%
2.0	23.96	0.77%	0.77%	0.349	0.349	0.32%
2.5	29.23	1.36%	1.36%	0.347	0.347	0.57%
3.0	34.19	2.11%	2.11%	0.342	0.342	0.89%
3.5	38.87	3.00%	3.00%	0.337	0.337	1.29%
4.0	43.25	3.99%	3.99%	0.331	0.331	1.73%
4.5	47.34	5.08%	5.08%	0.323	0.323	2.23%

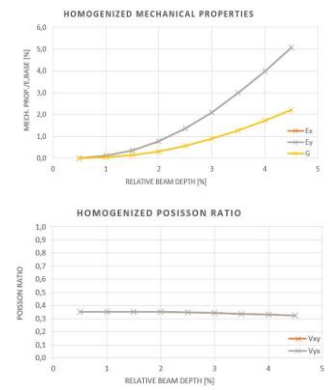
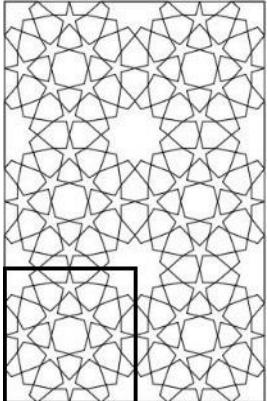


TABLE AP1.2.47. Pattern Q55. Homogenized mechanical properties with beams FE



Q65		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
0.5	6.70	0.01%	0.01%	0.253	0.253	0.00%
1.0	13.10	0.11%	0.11%	0.256	0.256	0.04%
1.5	19.19	0.34%	0.34%	0.260	0.260	0.12%
2.0	24.99	0.73%	0.73%	0.263	0.263	0.28%
2.5	30.49	1.29%	1.29%	0.265	0.265	0.50%
3.0	35.69	2.00%	2.00%	0.266	0.266	0.79%
3.5	40.59	2.83%	2.83%	0.264	0.264	1.15%
4.0	45.18	3.76%	3.76%	0.262	0.262	1.56%
4.5	49.48	4.78%	4.78%	0.257	0.257	2.01%

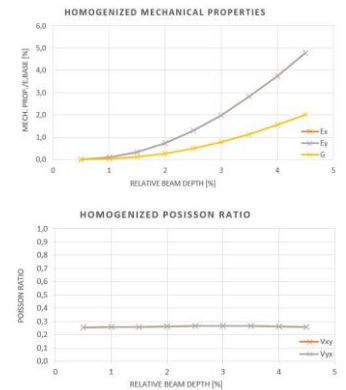
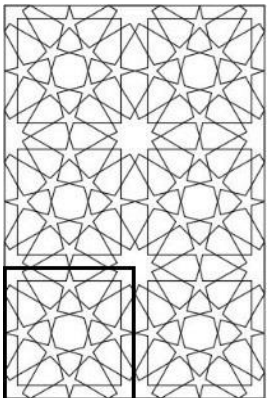


TABLE AP1.2.48. Pattern Q65. Homogenized mechanical properties with beams FE



Q75		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
0.5	7.13	0.01%	0.01%	0.267	0.267	0.00%
1.0	13.93	0.09%	0.09%	0.270	0.270	0.03%
1.5	20.41	0.30%	0.30%	0.273	0.273	0.10%
2.0	26.55	0.65%	0.65%	0.275	0.275	0.23%
2.5	32.37	1.14%	1.14%	0.275	0.275	0.42%
3.0	37.85	1.77%	1.77%	0.273	0.273	0.67%
3.5	43.01	2.51%	2.51%	0.270	0.270	0.98%
4.0	47.83	3.35%	3.35%	0.264	0.264	1.34%
4.5	52.33	4.28%	4.28%	0.257	0.257	1.75%

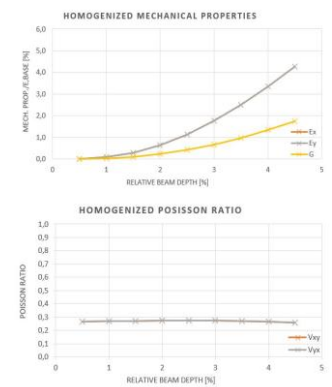
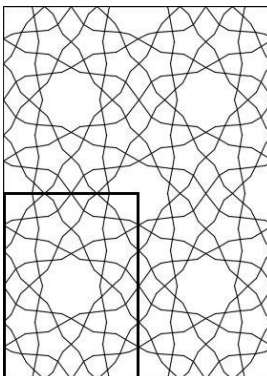


TABLE AP1.2.49. Pattern Q75. Homogenized mechanical properties with beams FE

R) FATEHPUR SIKRI. Tessellation ROS-I-6.10.10. type Star



R48		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	11.68	0.29%	0.57%	0.517	1.016	0.38%
2	22.46	1.79%	3.08%	0.477	0.821	1.70%
3	32.35	4.45%	6.84%	0.436	0.670	3.42%
4	41.33	7.83%	11.08%	0.401	0.567	5.26%
5	49.41	11.59%	15.51%	0.372	0.498	7.17%
6	56.58	15.55%	20.01%	0.350	0.450	9.12%
7	62.86	19.61%	24.53%	0.331	0.415	11.08%
x	x	x	x	x	x	x

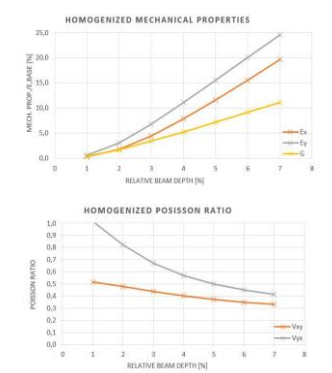
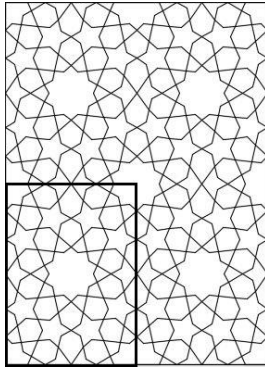
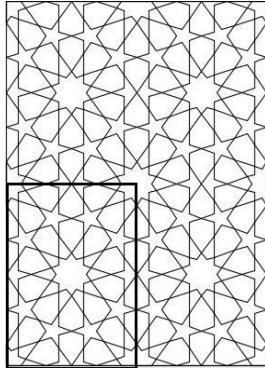
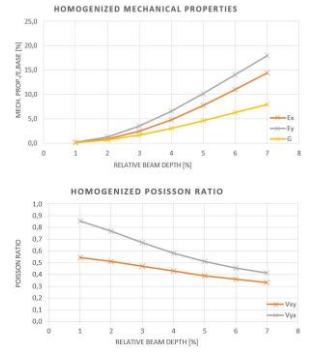


TABLE AP1.2.50. Pattern R48. Homogenized mechanical properties with beams FE



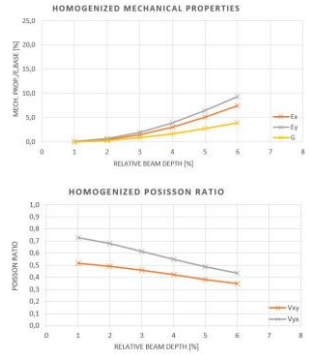
R60		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	12.46	0.12%	0.19%	0.546	0.853	0.11%
2	23.97	0.88%	1.31%	0.512	0.768	0.69%
3	34.55	2.49%	3.55%	0.470	0.670	1.73%
4	44.19	4.86%	6.61%	0.428	0.583	3.07%
5	52.90	7.76%	10.18%	0.390	0.512	4.61%
6	60.66	11.01%	14.02%	0.358	0.456	6.27%
7	67.49	14.46%	18.00%	0.331	0.412	8.01%
8	x	x	x	x	x	x

TABLE AP1.2.51. Pattern R60. Homogenized mechanical properties with beams FE

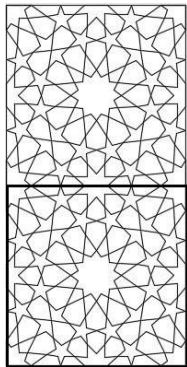


R72		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
1	13.86	0.07%	0.10%	0.517	0.730	0.04%
2	26.49	0.50%	0.69%	0.493	0.680	0.30%
3	37.90	1.49%	2.00%	0.458	0.615	0.86%
4	48.08	3.06%	3.99%	0.420	0.548	1.68%
5	57.03	5.11%	6.50%	0.382	0.486	2.72%
6	64.76	7.52%	9.37%	0.348	0.433	3.94%
7	x	x	x	x	x	x
8	x	x	x	x	x	x

TABLE AP1.2.52. Pattern R72. Homogenized mechanical properties with beams FE

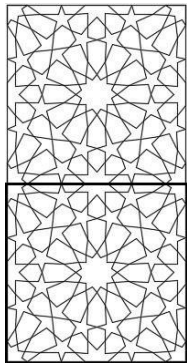
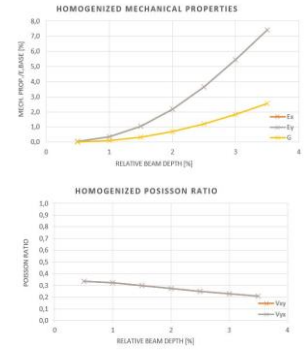


S) JAMEH MOSQUE. Tessellation ROS-I-6.12.8.12. $\theta = 70^\circ$, Type Star



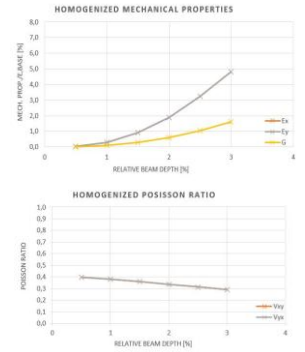
S20		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
0.5	10.94	0.04%	0.04%	0.344	0.344	0.02%
1.0	21.14	0.33%	0.33%	0.326	0.326	0.11%
1.5	30.61	1.01%	1.01%	0.300	0.300	0.34%
2.0	39.34	2.12%	2.12%	0.271	0.271	0.70%
2.5	47.33	3.60%	3.60%	0.243	0.243	1.20%
3.0	54.59	5.38%	5.38%	0.217	0.217	1.81%
3.5	61.10	7.37%	7.37%	0.194	0.194	2.51%
4	x	x	x	x	x	x

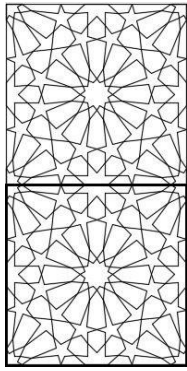
TABLE AP1.2.53. Pattern S20. Homogenized mechanical properties with beams FE



S35		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
0.5	11.20	0.04%	0.04%	0.396	0.396	0.01%
1.0	21.62	0.32%	0.32%	0.382	0.382	0.09%
1.5	31.25	0.97%	0.97%	0.363	0.363	0.28%
2.0	40.10	2.01%	2.01%	0.341	0.341	0.61%
2.5	48.16	3.38%	3.38%	0.318	0.318	1.06%
3.0	55.44	5.03%	5.03%	0.296	0.296	1.64%
3.5	x	x	x	x	x	x
4	x	x	x	x	x	x

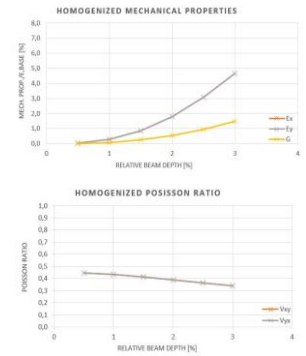
TABLE AP1.2.54. Pattern S35. Homogenized mechanical properties with beams FE



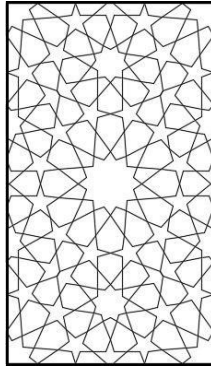


S50		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
0.5	11.50	0.04%	0.04%	0.448	0.448	0.01%
1.0	22.16	0.28%	0.28%	0.434	0.434	0.08%
1.5	31.97	0.87%	0.87%	0.413	0.413	0.25%
2.0	40.95	1.82%	1.82%	0.388	0.388	0.54%
2.5	49.08	3.10%	3.10%	0.364	0.364	0.95%
3.0	56.37	4.65%	4.65%	0.340	0.340	1.47%
3.5	x	x	x	x	x	x
4	x	x	x	x	x	x

TABLE AP1.2.55. Pattern S50. Homogenized mechanical properties with beams FE

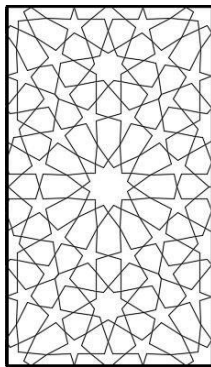
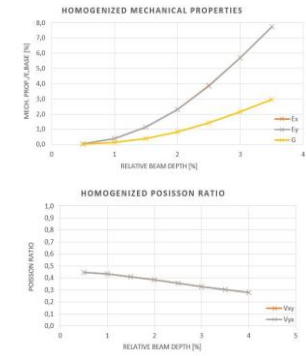


T) ALHAMBRA. Tessellation ROS-I-6.9.12.9. $\theta = 70^\circ$



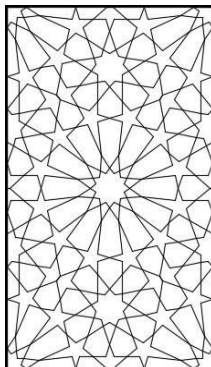
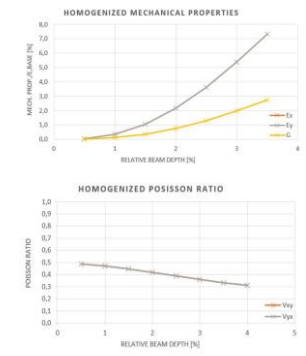
T20		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
0.5	10.56	0.04%	0.04%	0.448	0.448	0.01%
1.0	20.43	0.32%	0.32%	0.435	0.435	0.11%
1.5	29.61	0.97%	0.97%	0.414	0.414	0.34%
2.0	38.09	2.01%	2.01%	0.389	0.389	0.72%
2.5	45.89	3.40%	3.40%	0.362	0.362	1.24%
3.0	53.00	5.07%	5.06%	0.336	0.336	1.89%
3.5	59.41	6.95%	6.95%	0.311	0.311	2.64%
4.0	65.14	8.99%	8.98%	0.288	0.288	3.48%

TABLE AP1.2.56. Pattern T20. Homogenized mechanical properties with beams FE



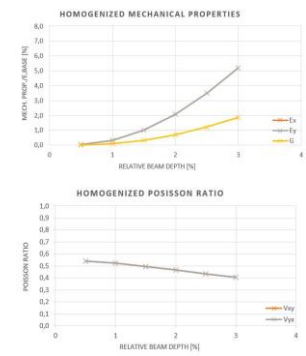
T35		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
0.5	10.75	0.04%	0.04%	0.488	0.488	0.01%
1.0	20.78	0.30%	0.30%	0.473	0.473	0.10%
1.5	30.08	0.90%	0.90%	0.451	0.451	0.31%
2.0	38.67	1.88%	1.88%	0.425	0.425	0.66%
2.5	46.54	3.19%	3.19%	0.397	0.397	1.14%
3.0	53.68	4.77%	4.77%	0.370	0.370	1.74%
3.5	60.11	6.56%	6.56%	0.344	0.344	2.44%
4.0	65.81	8.51%	8.50%	0.320	0.320	3.22%

TABLE AP1.2.57. Pattern T35. Homogenized mechanical properties with beams FE



T50		HOMOGENIZED MECHANICAL PROPERTIES				
rbd [%]	Sat [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
0.5	10.95	0.04%	0.04%	0.542	0.542	0.01%
1.0	21.15	0.28%	0.28%	0.525	0.525	0.09%
1.5	30.60	0.86%	0.86%	0.501	0.501	0.28%
2.0	39.30	1.80%	1.80%	0.473	0.473	0.61%
2.5	47.24	3.07%	3.07%	0.443	0.443	1.06%
3.0	54.43	4.61%	4.61%	0.414	0.414	1.63%
3.5	x	x	x	x	x	x
4.0	x	x	x	x	x	x

TABLE AP1.2.58. Pattern T50. Homogenized mechanical properties with beams FE



The homogenized mechanical properties are normalized dividing the results by the base material modulus of elasticity (E_{base}). A fully continuous opaque panel has a homogenized modulus of elasticity of 1 (100%), so a value of 5.69% for the homogenized modulus of elasticity (E) means that it will have a modulus of elasticity that is 5.69% of a fully filled panel with the same thickness. The results are obtained with beam elements in a linear elastic analysis. Therefore, it does not have into account effects such as overlaps as the pattern grows opaquer or non-linear effects derived from the different stress levels inside the pattern.

3. MEMBRANE CORRECTION FACTOR (C_{2D})

The membrane correction factor (C_{2D}) is defined as the relation between the homogenized mechanical properties obtained with membrane elements (2D) and those obtained with beam elements (1D). It takes into account the effect that bars overlaps have on the nodes' stiffness and on the reduction of the effective bars' length. These effects stiffen the structure, so their values are expected to be bigger than 1. increasing with the relative beam depth for shear and Young's modulus and decreasing for the Poisson ratio. It corresponds to the third stage in the scheme described in Chapter 4.2. *Homogenization methodology*.

A) YESLI MOSQUE. Tessellation 3.6.3.6.

A0	C2D CORRECTION FACTORS				
rbd [%]	C2D_EX	C2D_EY	C2D_VXY	C2D_VYX	C2D_G
2	1.01	1.01	1.00	1.00	1.01
4	1.01	1.01	0.99	0.99	1.02
6	1.02	1.02	0.99	0.99	1.02
8	1.03	1.03	0.98	0.98	1.03
10	1.03	1.03	0.98	0.98	1.04
12	1.04	1.04	0.97	0.97	1.04
14	1.05	1.05	0.97	0.97	1.05
16	1.05	1.05	0.96	0.96	1.05
18	1.06	1.06	0.96	0.96	1.06
20	1.06	1.06	0.96	0.96	1.06

TABLE AP1.3.1. Membrane correction factors pattern A

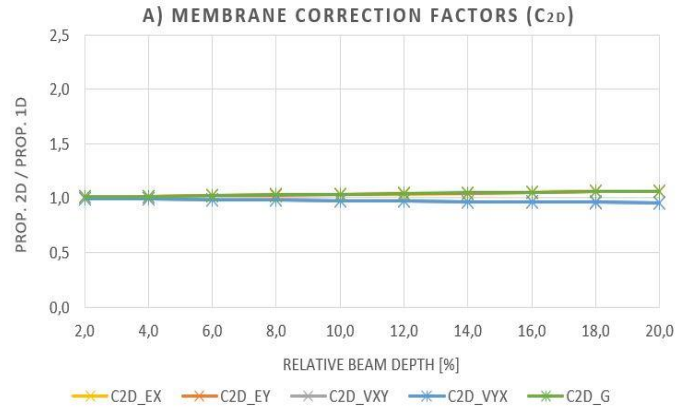


FIG AP1.3.1. Membrane correction factors pattern A

B) GREAT MOSQUE OF DAMASCUS. Tessellation 6.6.6. $\theta = 60^\circ$

B60	C2D CORRECTION FACTORS				
rbd [%]	C2D_EX	C2D_EY	C2D_VXY	C2D_VYX	C2D_G
1	1.01	1.01	1.02	1.02	0.81
2	1.11	1.10	1.05	1.05	0.86
3	1.19	1.18	1.09	1.09	0.93
4	1.30	1.30	1.12	1.13	1.03
5	1.41	1.42	1.16	1.17	1.14
6	1.56	1.56	1.20	1.20	1.28
7	1.71	1.71	1.22	1.23	1.42
8	1.83	1.83	1.25	1.25	1.54
9	2.01	2.02	1.26	1.26	1.73
10	2.15	2.14	1.27	1.26	1.87

TABLE AP1.3.2. Membrane correction factors pattern B

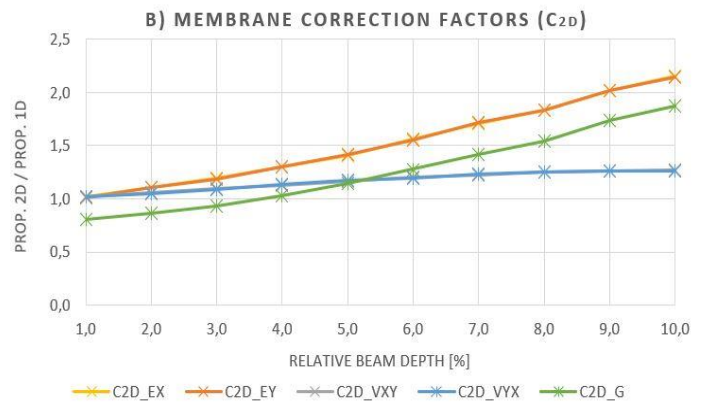


FIG AP1.3.2. Membrane correction factors pattern B

B75	C2D CORRECTION FACTORS				
rbd [%]	C2D_EX	C2D_EY	C2D_VXY	C2D_VYX	C2D_G
1	1.14	1.15	1.06	1.06	0.94
2	1.41	1.40	1.15	1.14	1.14
3	1.76	1.76	1.23	1.23	1.41
4	2.22	2.22	1.32	1.32	1.76
5	2.88	2.87	1.43	1.42	2.27
6	3.81	3.74	1.53	1.50	2.94
7	4.87	4.82	1.57	1.56	3.82
8	5.99	5.99	1.53	1.53	4.84
9	6.82	6.80	1.43	1.43	5.65
10	7.12	7.14	1.36	1.37	6.10

TABLE AP1.3.3. Membrane correction factors pattern B75

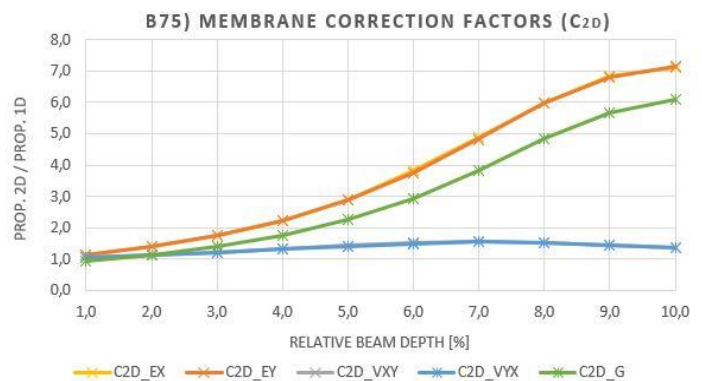


FIG AP1.3.3. Membrane correction factors pattern B75

C) SABZ PUSHAN. Tessellation 6.6.6 $\theta = 60^\circ$, opening distance 35%

C35	C2D CORRECTION FACTORS				
rbd [%]	C _{2D_EX}	C _{2D_EY}	C _{2D_VXY}	C _{2D_VYX}	C _{2D_G}
1	1.05	1.04	1.02	1.01	0.84
2	1.18	1.17	1.04	1.03	0.93
3	1.32	1.30	1.06	1.05	1.05
4	1.48	1.47	1.08	1.07	1.20
5	1.70	1.70	1.08	1.08	1.41
6	1.87	1.87	1.09	1.09	1.57
7	1.99	2.01	1.10	1.11	1.70

TABLE AP1.3.4. Membrane correction factors pattern C

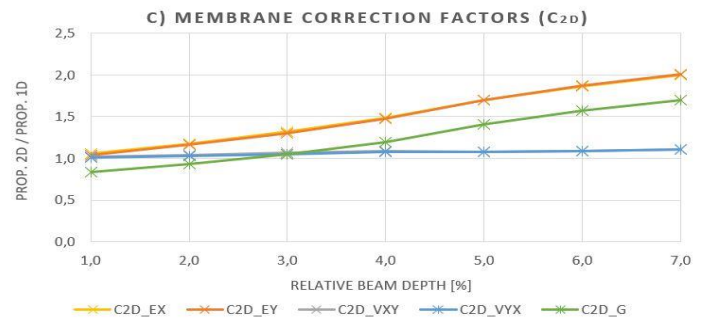


FIG AP1.3.4. Membrane correction factors pattern C

D) LAHORE FORT COMPLEX. Tessellation 4.8.8. $\theta = 67.5^\circ$

D67.5	C2D CORRECTION FACTORS				
rbd [%]	C _{2D_EX}	C _{2D_EY}	C _{2D_VXY}	C _{2D_VYX}	C _{2D_G}
2	1.08	1.08	1.18	1.18	0.94
3	1.15	1.15	1.28	1.29	0.98
4	1.19	1.19	1.34	1.34	1.16
5	1.23	1.23	1.38	1.38	1.34
6	1.25	1.25	1.40	1.40	1.53
7	1.27	1.27	1.40	1.40	1.66
8	1.30	1.30	1.41	1.41	1.78

TABLE AP1.3.5. Membrane correction factors pattern D

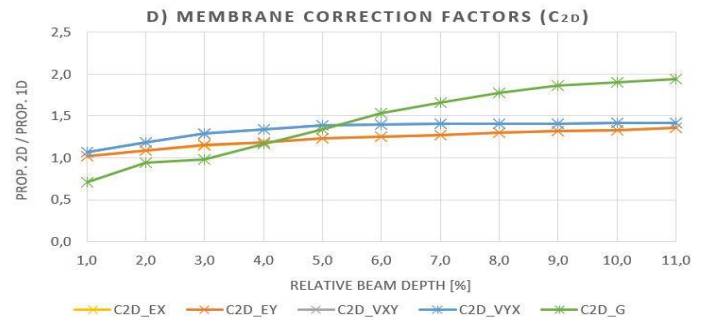


FIG AP1.3.5. Membrane correction factors pattern D

E) PALACE OF THE SHIRVANSHAHS. Tessellation 4.8.8. $\theta = 45^\circ$, with number of crossings = 0

E45	C2D CORRECTION FACTORS				
rbd [%]	C _{2D_EX}	C _{2D_EY}	C _{2D_VXY}	C _{2D_VYX}	C _{2D_G}
3	3.56	3.56	0.99	0.99	1.90
4	3.69	3.69	0.99	0.99	1.82
5	3.82	3.82	0.98	0.98	1.76
6	3.92	3.92	0.98	0.98	1.73
7	4.13	4.13	0.97	0.97	1.66
8	4.25	4.25	0.97	0.97	1.68
9	4.46	4.46	0.96	0.96	1.65
10	4.58	4.58	0.95	0.95	1.60

TABLE AP1.3.6. Membrane correction factors pattern E

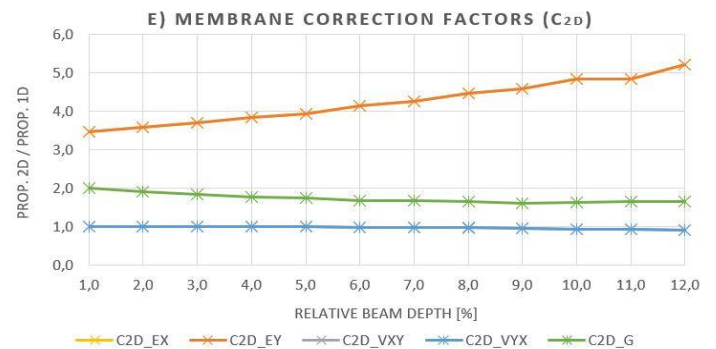


FIG AP1.3.6. Membrane correction factors pattern E

F) MUSTANSIRIYA MADRASA. Tessellation 3.6.3.6. $\theta = 30^\circ$

F30	C2D CORRECTION FACTORS				
rbd [%]	C _{2D_EX}	C _{2D_EY}	C _{2D_VXY}	C _{2D_VYX}	C _{2D_G}
3	1.06	1.06	1.00	1.00	0.73
4	1.14	1.14	1.00	1.00	0.80
5	1.20	1.20	1.00	1.00	0.84
6	1.30	1.30	0.99	0.99	0.93
7	1.37	1.37	0.99	0.99	0.97
8	1.47	1.48	0.97	0.97	1.08
9	1.58	1.58	0.96	0.96	1.20
10	1.69	1.69	0.94	0.93	1.28
11	1.79	1.78	0.91	0.91	1.40

TABLE AP1.3.7. Membrane correction factors pattern F

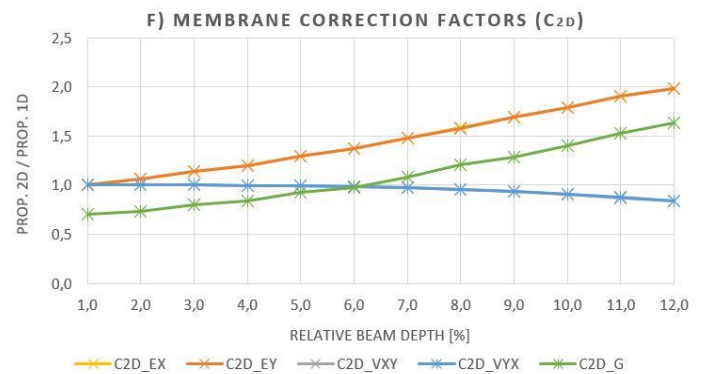


FIG AP1.3.7. Membrane correction factors pattern F

G) TOMB OF SALIM CHISHTI. Tessellation 6.6.6. $D = 65\%$, $\theta = 75^\circ$

G75	C2D CORRECTION FACTORS				
rbd [%]	C _{2D_EX}	C _{2D_EY}	C _{2D_VXY}	C _{2D_VYX}	C _{2D_G}
1	1.08	0.97	1.10	0.98	0.72
2	1.15	1.02	1.11	0.99	0.77
3	1.26	1.11	1.12	0.99	0.85
4	1.37	1.19	1.12	0.97	0.95
5	1.49	1.28	1.11	0.95	1.06
6	1.61	1.34	1.09	0.91	1.20
7	1.73	1.42	1.05	0.86	1.33
8	1.84	1.50	0.99	0.81	1.47

TABLE AP1.3.8. Membrane correction factors pattern G

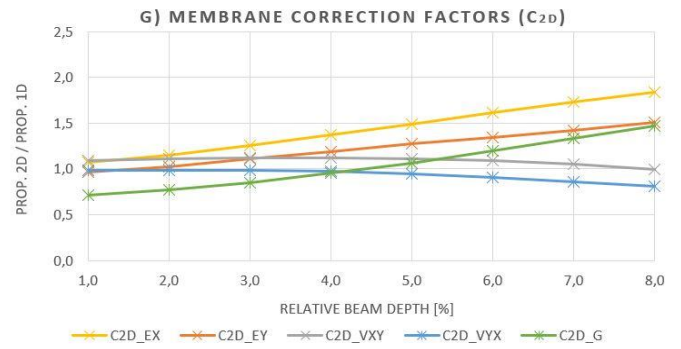


FIG AP1.3.8. Membrane correction factors pattern G

H) GENERALIFE. Tessellation 3.12.12. $\theta = 60^\circ$

H60	C2D CORRECTION FACTORS				
rbd [%]	C _{2D_EX}	C _{2D_EY}	C _{2D_VXY}	C _{2D_VYX}	C _{2D_G}
1	1.03	1.03	1.02	1.02	1.02
2	1.14	1.14	1.09	1.09	1.11
3	1.26	1.26	1.15	1.15	1.20
4	1.37	1.36	1.24	1.23	1.29
5	1.45	1.45	1.33	1.33	1.36
6	1.52	1.52	1.39	1.39	1.41
7	1.59	1.58	1.45	1.45	1.45

TABLE AP1.3.9. Membrane correction factors pattern H

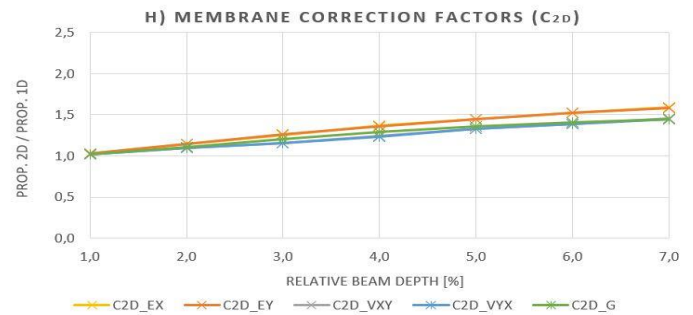


FIG AP1.3.9. Membrane correction factors pattern H

I) HASHT BEHESHT. Tessellation I-6.10.10. $\theta = 54^\circ$

I54	C2D CORRECTION FACTORS				
rbd [%]	C _{2D_EX}	C _{2D_EY}	C _{2D_VXY}	C _{2D_VYX}	C _{2D_G}
1	1.04	1.04	1.01	1.01	1.00
2	1.11	1.11	1.02	1.02	1.05
3	1.17	1.16	1.04	1.03	1.09
4	1.20	1.19	1.05	1.04	1.11
5	1.22	1.21	1.06	1.05	1.13
6	1.24	1.22	1.07	1.06	1.14
7	1.26	1.24	1.08	1.07	1.15
8	1.27	1.25	1.09	1.07	1.15

TABLE AP1.3.10. Membrane correction factors pattern I

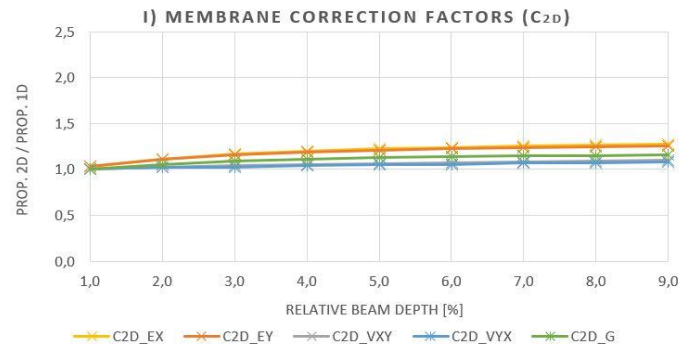


FIG AP1.3.10. Membrane correction factors pattern I

J) MODARI-KHAN MADRASH. Tessellation ROS-I-6.10.10. $\theta_1 = 45^\circ$, $\theta_2 = 60^\circ$. type Star

J45	C2D CORRECTION FACTORS				
rbd [%]	C _{2D_EX}	C _{2D_EY}	C _{2D_VXY}	C _{2D_VYX}	C _{2D_G}
0.5	0.99	0.99	1.00	1.00	1.06
1.0	1.03	1.04	1.00	1.01	0.96
2	1.14	1.15	1.00	1.00	1.07
3	1.25	1.23	0.99	0.97	1.19
4	1.33	1.29	0.96	0.93	1.26
5	1.39	1.34	0.95	0.91	1.32
6	1.45	1.38	0.94	0.89	1.35

TABLE AP1.3.11. Membrane correction factors pattern J

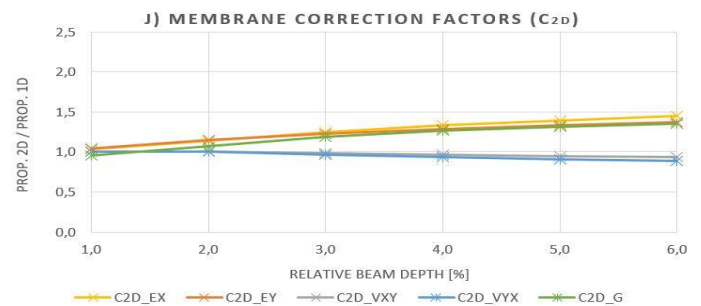


FIG AP1.3.11. Membrane correction factors pattern J

K) COMPLEX OF SULTAN BAYEZID II. Tessellation ROS-3.4.3.12.3.12.12. $\theta = 60^\circ$, type Bayezid

K60	C2D CORRECTION FACTORS				
rbd [%]	C _{2D_EX}	C _{2D_EY}	C _{2D_VXY}	C _{2D_VYX}	C _{2D_G}
1.0	1.09	1.09	1.00	1.00	1.02
1.5	1.17	1.17	1.00	1.00	1.12
2.0	1.24	1.24	1.00	1.00	1.23
2.5	1.33	1.33	0.99	0.99	1.36
3.0	1.42	1.42	0.97	0.97	1.46
3.5	1.50	1.50	0.96	0.96	1.58
4.0	1.60	1.60	0.94	0.94	1.71
4.5	1.69	1.69	0.93	0.93	1.82
5.0	1.79	1.79	0.90	0.90	1.91

TABLE AP1.3.12. Membrane correction factors pattern K

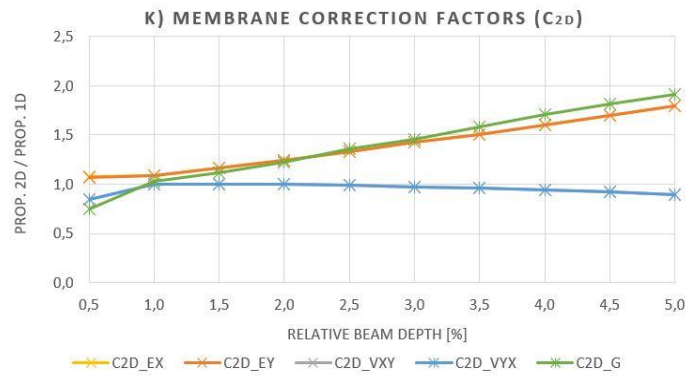


FIG AP1.3.12. Membrane correction factors pattern K

L) BEN YUSUF MADRASA. Tessellation ROS-3.4.3.12.3.12.12. $\theta = 75^\circ$, type Arrow

L75	C2D CORRECTION FACTORS				
rbd [%]	C _{2D_EX}	C _{2D_EY}	C _{2D_VXY}	C _{2D_VYX}	C _{2D_G}
1.0	1.17	1.17	1.03	1.03	1.06
1.5	1.32	1.32	1.08	1.08	1.15
2.0	1.48	1.48	1.14	1.14	1.26
2.5	1.67	1.67	1.20	1.20	1.40
3.0	1.85	1.85	1.24	1.24	1.53
3.5	2.07	2.07	1.28	1.28	1.69
4.0	2.26	2.26	1.34	1.34	1.80

TABLE AP1.3.13. Membrane correction factors pattern L

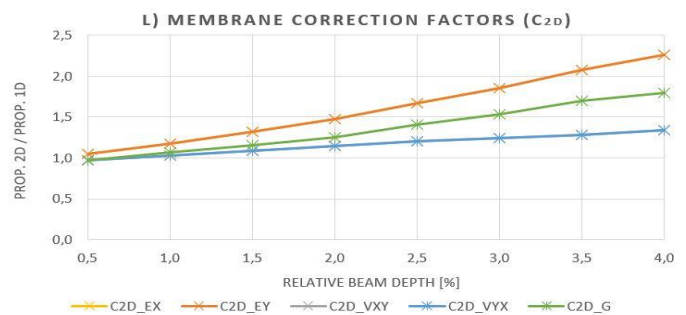


FIG AP1.3.13. Membrane correction factors pattern L

M) AL-NASIR MUHAMMAD'S MINBAR. Tessellation ROS-I-6.12.8.12. $\theta = 75^\circ$, L = 20%, type Arrow

M20	C2D CORRECTION FACTORS				
rbd [%]	C _{2D_EX}	C _{2D_EY}	C _{2D_VXY}	C _{2D_VYX}	C _{2D_G}
0.5	1.19	1.19	0.98	0.98	1.09
1.0	1.51	1.51	0.94	0.94	1.45
1.5	1.96	1.96	0.87	0.87	1.87
2.0	2.53	2.53	0.75	0.75	2.43
2.5	3.00	3.00	0.63	0.63	3.01
3.0	3.10	3.10	0.61	0.61	3.17

TABLE AP1.3.14. Membrane correction factors pattern M

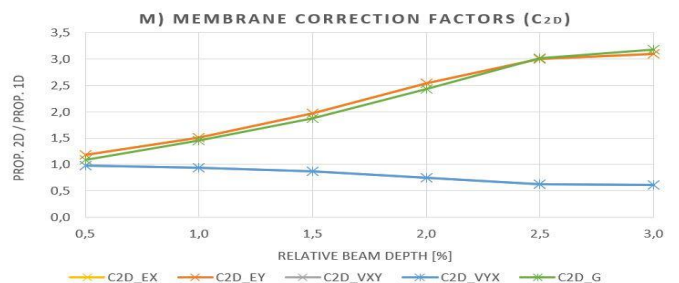


FIG AP1.3.14. Membrane correction factors pattern M

N) MOSQUE OF AL-NASIR MUHAMMAD. Tessellation ROS-3.12.12. $\theta = 75^\circ$, type Arrow

N75	C2D CORRECTION FACTORS				
rbd [%]	C _{2D_EX}	C _{2D_EY}	C _{2D_VXY}	C _{2D_VYX}	C _{2D_G}
1.0	1.20	1.21	0.99	0.99	1.18
1.5	1.37	1.38	1.03	1.03	1.33
2.0	1.58	1.58	1.07	1.08	1.53
2.5	1.80	1.79	1.13	1.12	1.72
3.0	2.06	2.05	1.18	1.18	1.97
3.5	2.29	2.27	1.21	1.21	2.16
4.0	2.49	2.49	1.26	1.26	2.33
4.5	2.61	2.61	1.32	1.32	2.44
5.0	2.70	2.71	1.38	1.39	2.50

TABLE AP1.3.15. Membrane correction factors pattern N

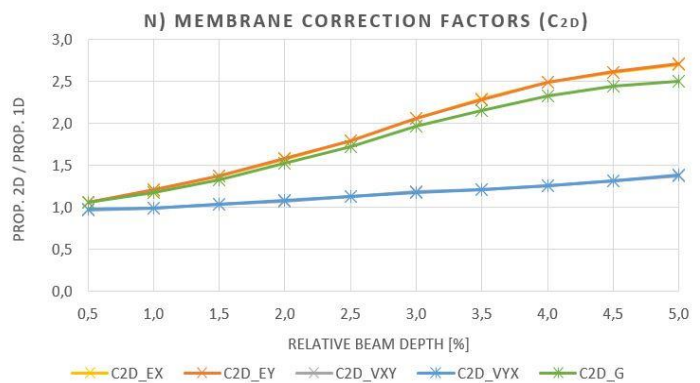


FIG AP1.3.15. Membrane correction factors pattern N

O) GREAT MOSQUE OF HERAT. Tessellation ROS-4.8.8. $\theta = 70^\circ$, $L = 30\%$

O30	C2D CORRECTION FACTORS				
rbd [%]	C _{2D_EX}	C _{2D_EY}	C _{2D_VXY}	C _{2D_VYX}	C _{2D_G}
1	1.09	1.09	1.04	1.04	0.95
2	1.29	1.29	1.07	1.07	1.10
3	1.47	1.47	1.12	1.12	1.29
4	1.68	1.67	1.15	1.15	1.54
5	1.87	1.87	1.16	1.16	1.82
6	2.03	2.03	1.17	1.17	2.14
7	2.17	2.17	1.15	1.15	2.49
8	2.30	2.30	1.12	1.12	2.88

TABLE AP1.3.16. Membrane correction factors pattern O

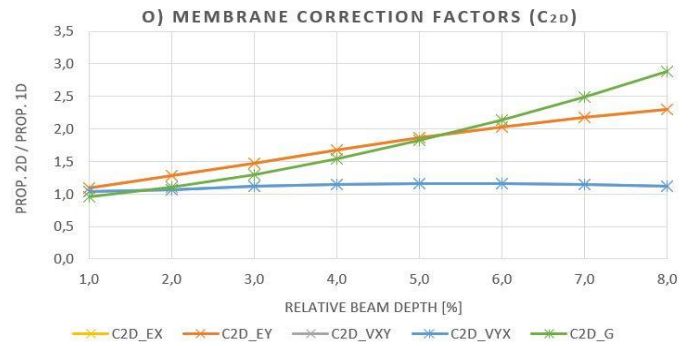


FIG AP1.3.16. Membrane correction factors pattern O

P) MOSQUE OF AL-SALIH TALA'I Tessellation ROS-3.4.3.8.3.8.8. $\theta = 75^\circ$, $L = 25\%$, type Star

P25	C2D CORRECTION FACTORS				
rbd [%]	C _{2D_EX}	C _{2D_EY}	C _{2D_VXY}	C _{2D_VYX}	C _{2D_G}
1.0	1.25	1.25	1.07	1.07	1.07
2.0	1.70	1.70	1.16	1.16	1.41
3.0	2.33	2.33	1.22	1.22	1.86
4.0	3.15	3.15	1.24	1.24	2.50
5.0	4.10	4.10	1.15	1.15	3.21
6.0	4.75	4.75	0.98	0.98	3.78

TABLE AP1.3.17. Membrane correction factors pattern P

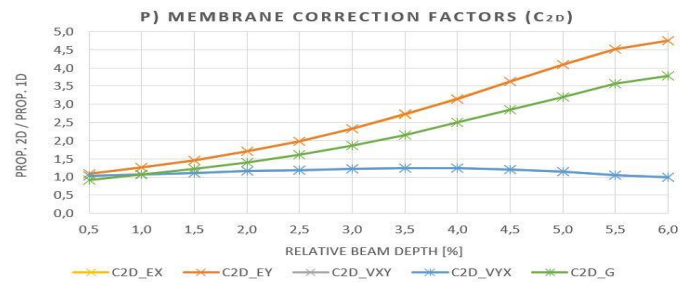


FIG AP1.3.17. Membrane correction factors pattern P

Q) MOSQUE OF IBN TULUN. Tessellation ROS-3.4.3.12.3.12.12. $\theta_1 = 75^\circ$, $\theta_2 = 65^\circ$, type Star

Q65	C2D CORRECTION FACTORS				
rbd [%]	C _{2D_EX}	C _{2D_EY}	C _{2D_VXY}	C _{2D_VYX}	C _{2D_G}
0.5	1.09	1.09	1.08	1.08	1.05
1.0	1.25	1.25	1.18	1.18	1.18
1.5	1.45	1.45	1.27	1.27	1.35
2.0	1.68	1.68	1.36	1.36	1.56
2.5	1.92	1.92	1.41	1.41	1.78
3.0	2.23	2.23	1.40	1.40	2.02
3.5	2.57	2.57	1.36	1.36	2.30
4.0	2.88	2.88	1.27	1.27	2.51
4.5	3.14	3.14	1.15	1.15	2.64

TABLE AP1.3.18. Membrane correction factors pattern Q

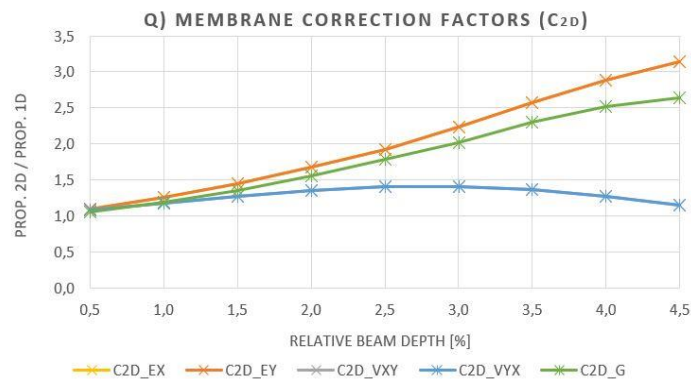


FIG AP1.3.18. Membrane correction factors pattern Q

R) FATEHPUR SIKRI. Tessellation ROS-I-6.10.10. $\theta = 72^\circ$ type Star

R72	C2D CORRECTION FACTORS				
rbd [%]	C _{2D_EX}	C _{2D_EY}	C _{2D_VXY}	C _{2D_VYX}	C _{2D_G}
0.5	1.08	1.08	1.01	1.01	1.00
1.0	1.24	1.24	1.02	1.03	1.16
2.0	1.68	1.68	1.05	1.05	1.50
3.0	2.31	2.25	1.05	1.02	1.93
4.0	3.07	2.85	0.99	0.92	2.41
5.0	3.67	3.26	0.87	0.78	2.76
6.0	3.90	3.34	0.82	0.71	2.85

TABLE AP1.3.19. Membrane correction factors pattern R

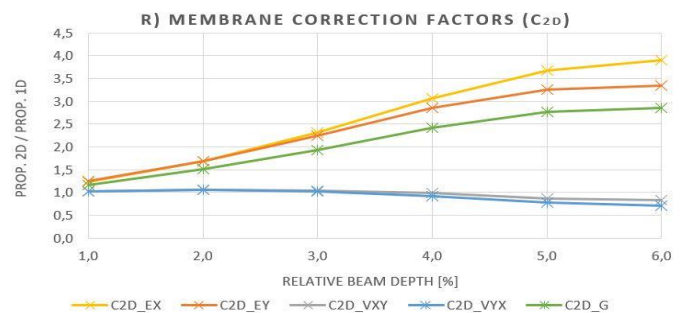


FIG AP1.3.19. Membrane correction factors pattern R

S) JAMEH MOSQUE. Tessellation ROS-I-6.12.8.12. $\theta = 70^\circ$, L =20%, Type Star

S20	C2D CORRECTION FACTORS				
rbd [%]	C _{2D_EX}	C _{2D_EY}	C _{2D_VXY}	C _{2D_VYX}	C _{2D_G}
0.5	1.11	1.11	1.07	1.07	1.14
1.0	1.40	1.40	1.13	1.13	1.40
1.5	1.78	1.77	1.19	1.19	1.73
2.0	2.21	2.21	1.25	1.25	2.17
2.5	2.65	2.65	1.29	1.29	2.66
3.0	2.99	2.99	1.32	1.32	3.07
3.5	3.13	3.13	1.40	1.40	3.37

TABLE AP1.3.20. Membrane correction factors pattern S

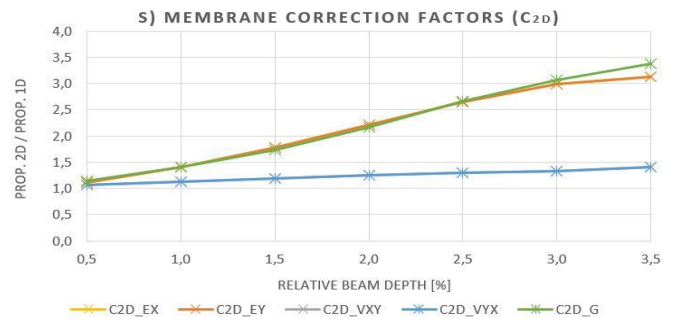


FIG AP1.3.20. Membrane correction factors pattern S

T) ALHAMBRA. Alhambra. Tessellation ROS-I-6.9.12.9. $\theta = 70^\circ$, L =35%

T35	C2D CORRECTION FACTORS				
rbd [%]	C _{2D_EX}	C _{2D_EY}	C _{2D_VXY}	C _{2D_VYX}	C _{2D_G}
0.5	1.15	1.15	1.06	1.06	1.10
1.0	1.44	1.43	1.11	1.10	1.35
1.5	1.76	1.76	1.15	1.14	1.65
2.0	2.13	2.12	1.16	1.15	2.02
2.5	2.51	2.49	1.14	1.13	2.39
3.0	2.83	2.82	1.08	1.08	2.75
3.5	3.06	3.04	1.03	1.03	3.02
4.0	3.19	3.16	1.03	1.02	3.14

TABLE AP1.3.21. Membrane correction factors pattern T

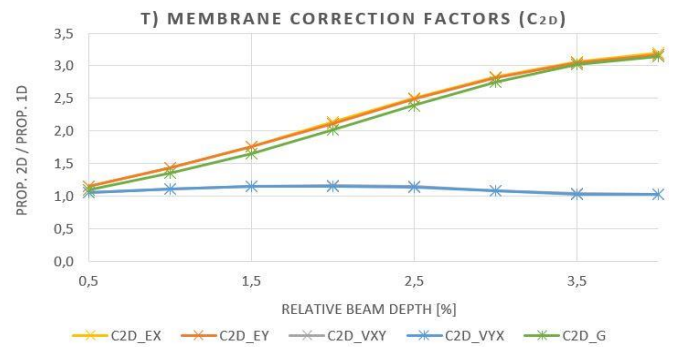


FIG AP1.3.21. Membrane correction factors pattern T

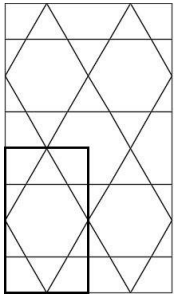
4. IDEAL HOMOGENIZED MECHANICAL PROPERTIES

This is last step in the homogenization process described in Chapter 4.2. Homogenization methodology. The application of the Membrane correction factors (C2D) to the homogenized mechanical properties introduce effects such as overlaps, reduction of effective beam length or transversal shortening of the beams in the homogenized mechanical properties obtained with beam elements with Representative Element Volume refinement.

This ideal behaviour is what will allow a fair comparison of the chosen historic patterns' performance. The saturation is a comparable parameter as it indicates the amount of material used, so the following tables are linearly interpolated to present the ideal homogenized mechanical properties with regards a varying saturation.

The information included in each case is (from left to right):

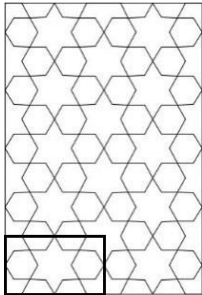
- Given name to the pattern and the tessellation and parameters to draw it with the Hankin method.
- Picture of the pattern displaying what is considered as its module. The module length in the x-direction (horizontally in the picture) is needed for the relative beam depth (rbd %) definition.
- Table of homogenized mechanical properties taking into account the Representative Element Volume
- Graphs with the evolution of the homogenized mechanical properties as the rbd increases.



A0		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	1.05	3.51%	3.51%	0.330	0.330	1.32%
20	2.16	7.38%	7.39%	0.325	0.325	2.78%
30	3.37	11.79%	11.79%	0.318	0.318	4.46%
40	4.71	16.93%	16.96%	0.308	0.308	6.43%
50	6.12	23.20%	23.21%	0.297	0.297	8.86%
60	X	-	-	-	-	-



TABLE AP1.4.1. Pattern A0. Ideal homogenized mechanical properties



B60		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	1.49	0.09%	0.09%	0.508	0.507	0.02%
20	3.05	0.58%	0.58%	0.506	0.505	0.15%
30	4.72	2.17%	2.19%	0.486	0.489	0.61%
40	6.51	5.63%	5.64%	0.456	0.457	1.68%
50	8.46	11.63%	11.65%	0.415	0.415	3.72%
60	10.63	20.77%	20.59%	0.367	0.364	7.02%

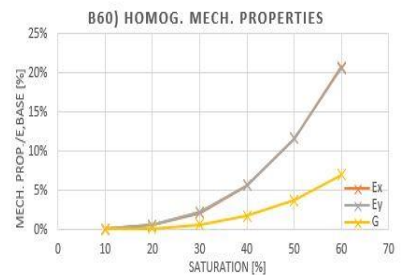
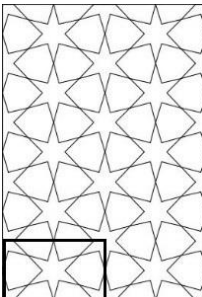


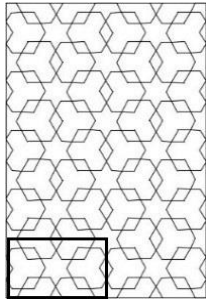
TABLE AP1.4.2. Pattern A0. Ideal homogenized mechanical properties



B75		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rel [%]	Ex	Ey	Vxy	Vyx	G
10	1.22	0.02%	0.02%	0.383	0.383	0.01%
20	2.52	0.19%	0.19%	0.409	0.409	0.06%
30	3.91	0.80%	0.80%	0.432	0.432	0.24%
40	5.45	3.10%	3.06%	0.450	0.445	0.92%
50	7.15	9.30%	9.23%	0.434	0.431	2.86%
60	9.10	22.51%	22.46%	0.349	0.348	7.50%



TABLE AP1.4.3. Pattern A0. Ideal homogenized mechanical properties



C35		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	1.15	0.05%	0.05%	0.756	0.748	0.01%
20	2.38	0.41%	0.41%	0.742	0.734	0.10%
30	3.70	1.51%	1.50%	0.708	0.703	0.36%
40	5.15	4.13%	4.13%	0.643	0.643	1.07%
50	6.77	8.99%	9.04%	0.574	0.577	2.50%
60	X	-	-	-	-	-

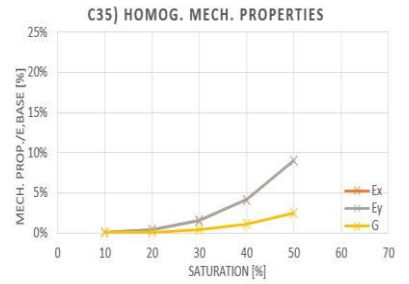
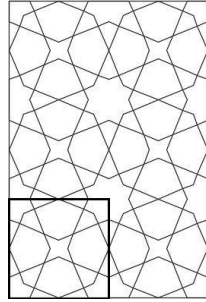


TABLE AP1.4.4. Pattern A0. Ideal homogenized mechanical properties



D67.5		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	1.40	0.59%	0.59%	0.216	0.216	0.03%
20	2.90	2.96%	2.96%	0.262	0.263	0.23%
30	4.52	7.25%	7.25%	0.297	0.297	0.98%
40	6.30	12.68%	12.67%	0.314	0.314	2.65%
50	8.31	19.31%	19.31%	0.315	0.315	5.52%
60	10.66	27.47%	27.47%	0.309	0.309	9.56%

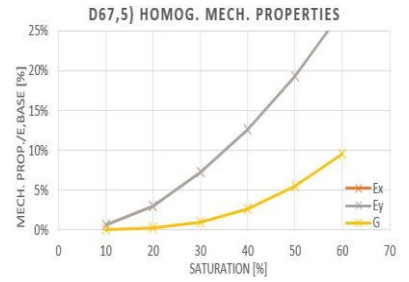
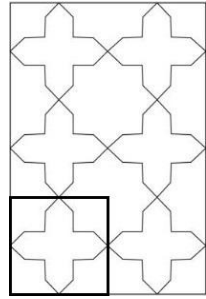


TABLE AP1.4.5. Pattern A0. Ideal homogenized mechanical properties



E45		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	2.05	0.02%	0.02%	0.877	0.877	0.02%
20	4.18	0.15%	0.15%	0.862	0.862	0.17%
30	6.41	0.56%	0.56%	0.838	0.838	0.55%
40	8.74	1.49%	1.49%	0.803	0.803	1.20%
50	11.19	3.24%	3.24%	0.762	0.762	2.28%
60	13.79	6.32%	6.32%	0.696	0.695	3.63%

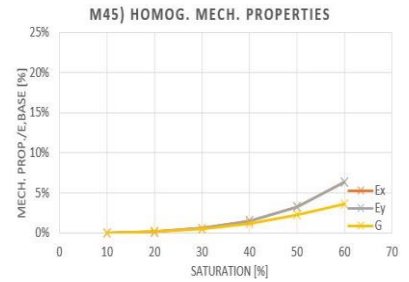
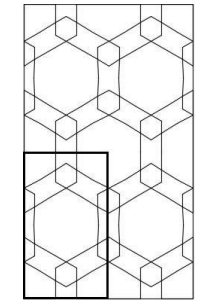


TABLE AP1.4.6. Pattern A0. Ideal homogenized mechanical properties



F30		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	2.07	0.04%	0.04%	0.973	0.973	0.01%
20	4.30	0.41%	0.42%	0.941	0.941	0.07%
30	6.73	1.69%	1.69%	0.877	0.878	0.32%
40	9.43	4.95%	4.93%	0.774	0.772	1.03%
50	12.52	11.61%	11.62%	0.626	0.626	2.74%
60	16.21	22.76%	22.87%	0.464	0.465	6.23%

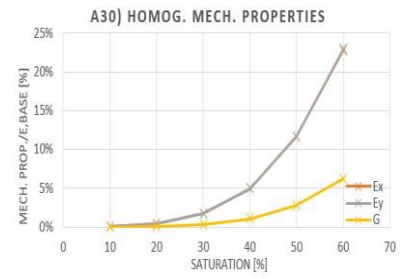
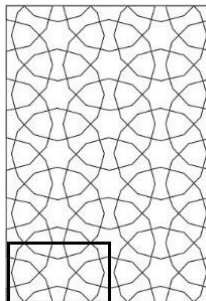


TABLE AP1.4.7. Pattern A0. Ideal homogenized mechanical properties



G75		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	1.06	0.07%	0.07%	0.973	0.877	0.01%
20	2.18	0.60%	0.53%	0.944	0.842	0.11%
30	3.35	2.12%	1.86%	0.887	0.780	0.41%
40	4.60	5.19%	4.47%	0.806	0.695	1.06%
50	5.94	10.26%	8.55%	0.711	0.594	2.29%
60	7.39	18.19%	14.92%	0.597	0.490	4.51%

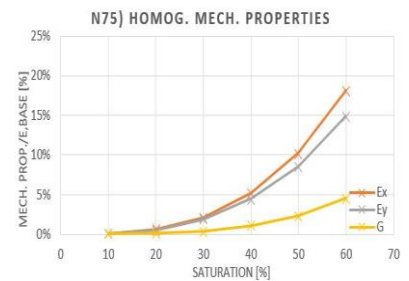
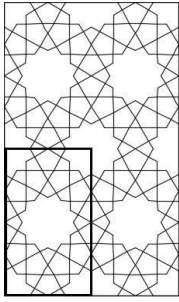


TABLE AP1.4.8. Pattern A0. Ideal homogenized mechanical properties



H60		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	1.16	0.27%	0.27%	0.110	0.109	0.12%
20	2.42	1.74%	1.75%	0.142	0.142	0.74%
30	3.78	4.98%	4.96%	0.182	0.181	2.04%
40	5.30	10.04%	10.05%	0.223	0.224	4.02%
50	7.03	16.90%	16.88%	0.256	0.256	6.56%
60	X	-	-	-	-	-

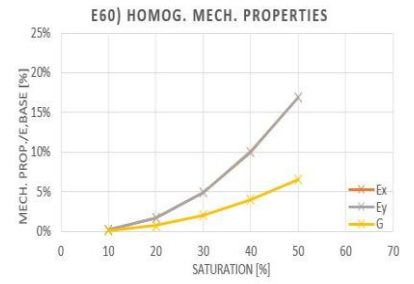
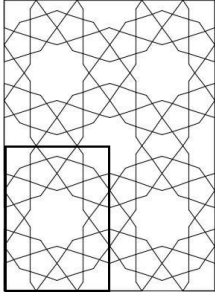


TABLE AP1.4.9. Pattern A0. Ideal homogenized mechanical properties



I54		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	1.13	0.58%	0.68%	0.268	0.316	0.23%
20	2.35	3.13%	3.46%	0.291	0.325	1.21%
30	3.69	7.32%	7.77%	0.308	0.327	2.78%
40	5.17	12.62%	13.05%	0.315	0.326	4.72%
50	6.88	19.06%	19.33%	0.318	0.322	7.05%
60	8.95	27.16%	27.08%	0.315	0.314	10.01%

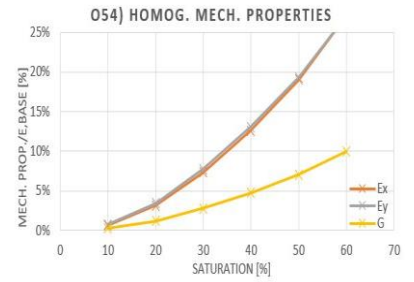
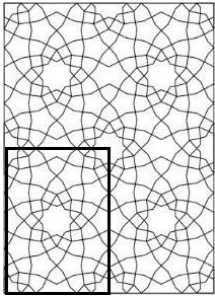


TABLE AP1.4.10. Pattern A0. Ideal homogenized mechanical properties



J45		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	0.72	0.19%	0.27%	0.676	0.934	0.10%
20	1.53	1.60%	2.00%	0.619	0.800	0.72%
30	2.37	4.44%	5.19%	0.547	0.655	1.94%
40	3.29	9.29%	10.19%	0.471	0.522	3.93%
50	4.31	16.21%	16.88%	0.404	0.422	6.67%
60	5.49	25.37%	25.33%	0.352	0.352	10.17%

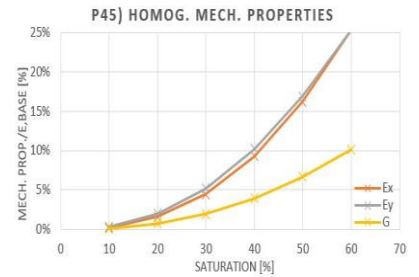
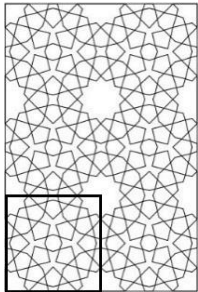


TABLE AP1.4.11. Pattern A0. Ideal homogenized mechanical properties



K60		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	0.73	0.11%	0.11%	0.600	0.600	0.02%
20	1.49	0.67%	0.67%	0.603	0.603	0.17%
30	2.33	1.99%	1.98%	0.542	0.542	0.57%
40	3.24	5.12%	5.12%	0.482	0.482	1.78%
50	4.25	9.93%	9.93%	0.423	0.423	3.86%
60	X	-	-	-	-	-

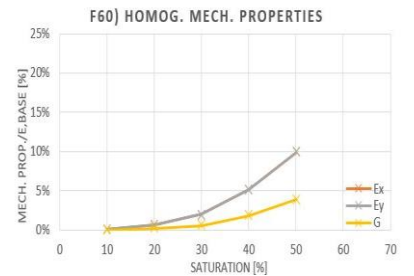
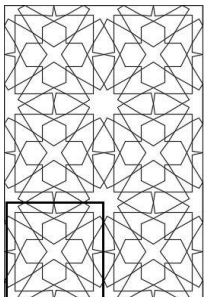


TABLE AP1.4.12. Pattern A0. Ideal homogenized mechanical properties



L75		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	0.75	0.08%	0.08%	0.189	0.189	0.02%
20	1.55	0.55%	0.55%	0.222	0.222	0.16%
30	2.42	2.09%	2.09%	0.261	0.261	0.64%
40	3.39	5.47%	5.46%	0.290	0.290	1.75%
50	X	-	-	-	-	-
60	X	-	-	-	-	-

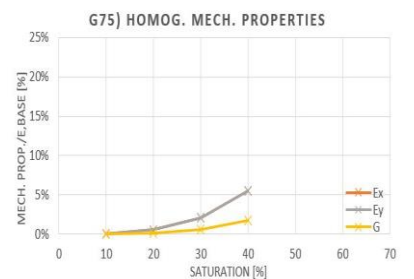
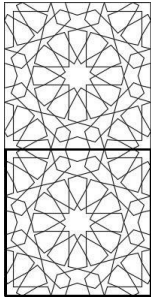


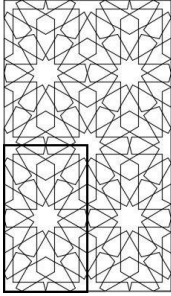
TABLE AP1.4.13. Pattern A0. Ideal homogenized mechanical properties



M20		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	0.45	0.01%	0.01%	0.755	0.755	0.00%
20	0.93	0.52%	0.52%	0.690	0.690	0.12%
30	1.45	2.17%	2.17%	0.593	0.593	0.49%
40	2.03	6.56%	6.56%	0.459	0.459	1.59%
50	2.69	14.78%	14.78%	0.341	0.341	3.98%
60	X	-	-	-	-	-



TABLE AP1.4.14. Pattern A0. Ideal homogenized mechanical properties



N75		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	0.74	0.08%	0.08%	0.195	0.196	0.03%
20	1.54	0.61%	0.58%	0.214	0.214	0.23%
30	2.39	2.36%	1.97%	0.236	0.237	0.79%
40	3.34	6.35%	5.95%	0.259	0.258	2.35%
50	4.39	12.81%	12.70%	0.265	0.266	4.91%
60	X	-	-	-	-	-

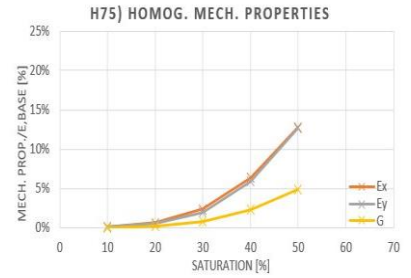
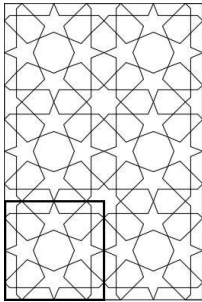


TABLE AP1.4.15. Pattern A0. Ideal homogenized mechanical properties



O30		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	1.06	0.09%	0.09%	0.430	0.430	0.01%
20	2.19	0.76%	0.76%	0.438	0.438	0.09%
30	3.41	2.75%	2.74%	0.444	0.444	0.36%
40	4.74	6.77%	6.78%	0.430	0.430	1.06%
50	6.23	13.63%	13.63%	0.396	0.396	2.71%
60	7.94	24.07%	24.06%	0.343	0.343	6.23%

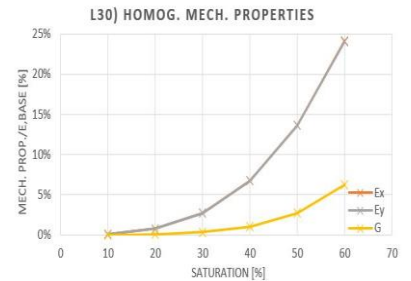
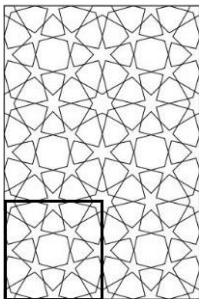


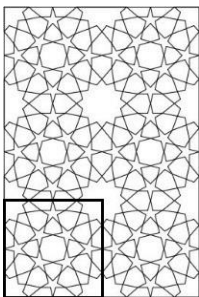
TABLE AP1.4.16. Pattern A0. Ideal homogenized mechanical properties



P25		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	0.82	0.03%	0.03%	0.490	0.490	0.01%
20	1.73	0.30%	0.30%	0.514	0.514	0.10%
30	2.69	1.34%	1.34%	0.528	0.528	0.42%
40	3.76	4.49%	4.49%	0.516	0.516	1.41%
50	4.96	11.27%	11.27%	0.454	0.454	3.55%
60	6.33	24.99%	24.99%	0.324	0.324	8.22%



TABLE AP1.4.17. Pattern A0. Ideal homogenized mechanical properties



Q65		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	0.76	0.08%	0.08%	0.288	0.288	0.03%
20	1.57	0.59%	0.59%	0.333	0.333	0.20%
30	2.46	2.37%	2.37%	0.373	0.373	0.85%
40	3.44	6.92%	6.92%	0.362	0.362	2.51%
50	4.56	15.54%	15.54%	0.292	0.292	5.50%
60	X	-	-	-	-	-

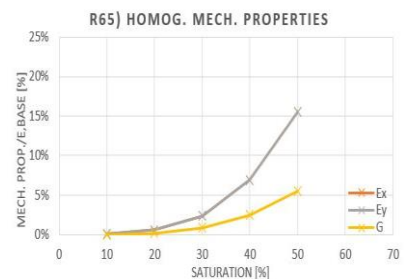
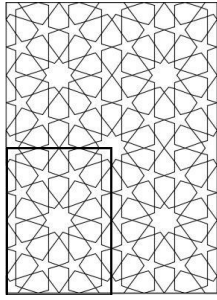


TABLE AP1.4.18. Pattern A0. Ideal homogenized mechanical properties



R72		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	0.69	0.04%	0.05%	0.529	0.752	0.02%
20	1.49	0.45%	0.62%	0.524	0.733	0.25%
30	2.31	1.64%	2.18%	0.506	0.689	0.83%
40	3.21	4.67%	5.91%	0.467	0.602	2.15%
50	4.21	11.39%	13.46%	0.399	0.476	4.80%
60	5.38	22.80%	25.07%	0.316	0.349	8.94%

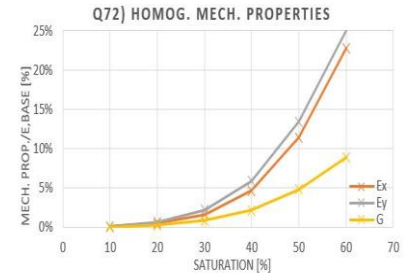
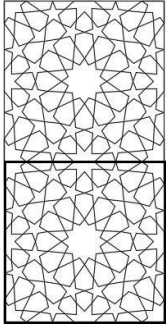


TABLE AP1.4.19. Pattern A0. Ideal homogenized mechanical properties



S20		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	0.45	0.01%	0.01%	0.366	0.366	0.00%
20	0.94	0.42%	0.42%	0.369	0.369	0.14%
30	1.47	1.71%	1.71%	0.359	0.359	0.55%
40	2.04	5.07%	5.08%	0.337	0.337	1.66%
50	2.68	11.94%	11.94%	0.304	0.304	4.05%
60	3.42	21.91%	21.91%	0.274	0.274	7.97%

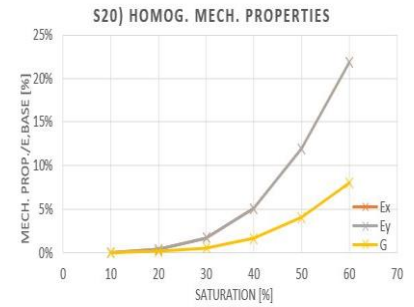
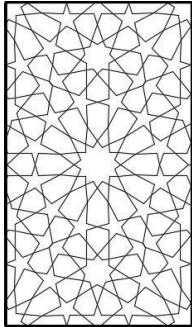


TABLE AP1.4.20. Pattern A0. Ideal homogenized mechanical properties



T35		HOMOGENIZED MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
10	0.46	0.02%	0.02%	0.516	0.516	0.01%
20	0.96	0.40%	0.40%	0.524	0.522	0.13%
30	1.50	1.58%	1.58%	0.517	0.515	0.51%
40	2.08	4.69%	4.65%	0.488	0.484	1.57%
50	2.74	10.69%	10.62%	0.428	0.425	3.73%
60	3.49	20.00%	19.86%	0.356	0.354	7.34%

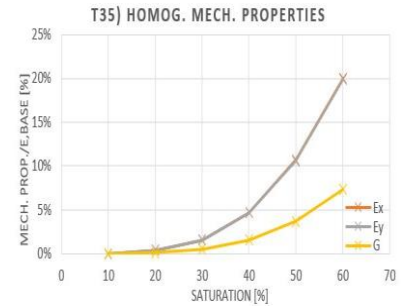


TABLE AP1.4.21. Pattern A0. Ideal homogenized mechanical properties

5. ROTATION FACTOR

The rotation coefficients vary with the relative beam depth, meaning that if a pattern is rotated a certain angle, the relation between the mechanical properties of the rotated pattern and the original pattern depends on the relative beam depth. For the homogenized modulus of elasticity and Poisson ratios, the variation is linear and can be defined by linear interpolation from two points. However, the variation of the shear modulus is curved and requires of three points if considered parabolic. For this reason, the rotation coefficients are provided for three different relative beam depths, so the designer can derive the approximate value for other relative beam depths. However, to get more accurate results and to rotate the variation patterns which are not included in this chapter, it is strongly recommended to retrieve the Q_{ij} coefficients and repeat the rotation process that has been shown step by step.

The test results for 2x2 and 4x4 panels to enable the calculation of the ideal behaviour are included here. The information included in each case from top to bottom is:

- Given name to the pattern and the tessellation and parameters to draw it with the Hankin method.
- Picture of the pattern displaying what is considered as its module. The module length in the x-direction (horizontally in the picture) is needed for the relative beam depth (rbd %) definition.
- Graph of the variation of the mechanical properties with a varying rotation, for a given relative beam depth
- Tables of the rotation factors of each mechanical property for a varying rotation, for a given saturation.

A) YESLI MOSQUE. Tessellation ROS-4.8.8. $\theta = 70^\circ$, L = 15%

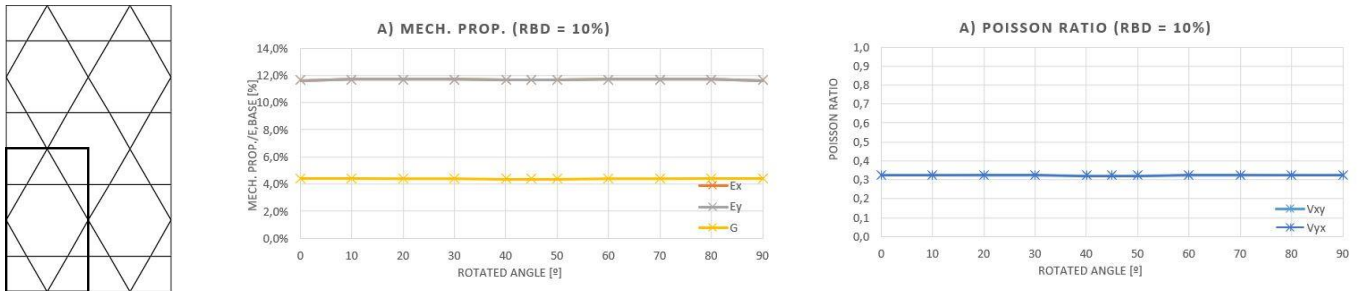


FIG AP1.5.1. Homogenized mechanical properties pattern A, for different pattern orientations.

4%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

10%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

8%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

TABLE AP1.5.1. Rotation factors pattern A, for different pattern orientations and saturations of 2%, 5% and 8%

B) GREAT MOSQUE OF DAMASCUS. Tessellation 6.6.6. $\theta = 60^\circ$

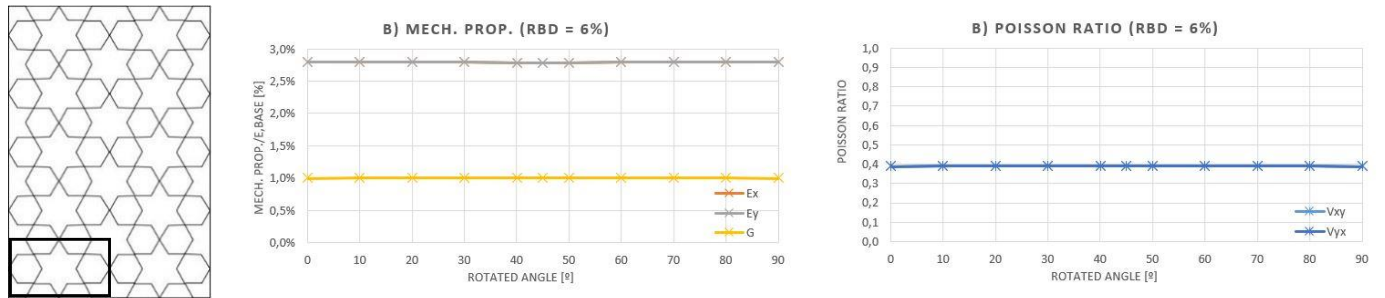


FIG AP1.5.2. Homogenized mechanical properties pattern B60. for different pattern orientations.

2%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

6%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

10%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

TABLE AP1.5.2. Rotation factors pattern B, for different pattern orientations and saturations of 2%, 6% and 10%

GREAT MOSQUE OF DAMASCUS. Tessellation 6.6.6. $\theta = 75^\circ$

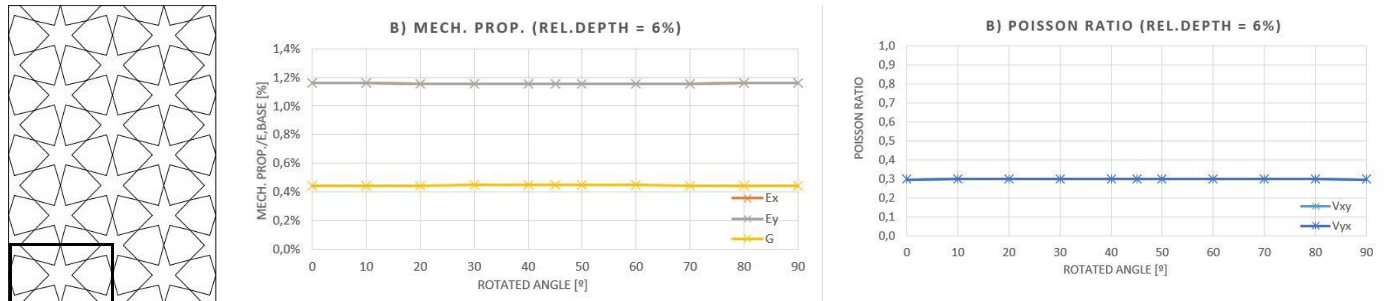


FIG AP1.5.3. Homogenized mechanical properties pattern B75. for different pattern orientations

2%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

6%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

10%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

TABLE AP1.5.3. Rotation factors pattern B75. for different pattern orientations and saturations of 2%, 6% and 10%

C) SABZ PUSHAN. Tessellation 6.6.6 $\theta = 60^\circ$, opening distance 35%

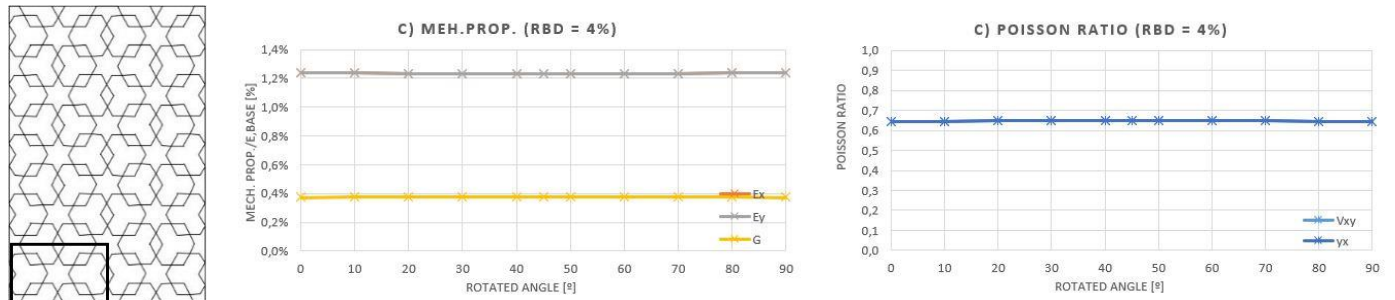


FIG AP1.5.4. Homogenized mechanical properties pattern C, for different pattern orientations.

2%						4%						6%					
ROTATION FACTORS						ROTATION FACTORS						ROTATION FACTORS					
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	10	1.00	1.00	1.00	1.00	1.00	10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00	20	1.00	1.00	1.00	1.00	1.00	20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00	30	1.00	1.00	1.00	1.00	1.00	30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00	40	1.00	1.00	1.00	1.00	1.00	40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00	45	1.00	1.00	1.00	1.00	1.00	45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00	50	1.00	1.00	1.00	1.00	1.00	50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00	60	1.00	1.00	1.00	1.00	1.00	60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00	70	1.00	1.00	1.00	1.00	1.00	70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00	80	1.00	1.00	1.00	1.00	1.00	80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00	90	1.00	1.00	1.00	1.00	1.00	90	1.00	1.00	1.00	1.00	1.00

TABLE AP1.5.4. Rotation factors pattern C, for different pattern orientations and saturations of 2%, 4% and 6%

D) LAHORE FORT COMPLEX. Tessellation 4.8.8. $\theta = 67.5^\circ$

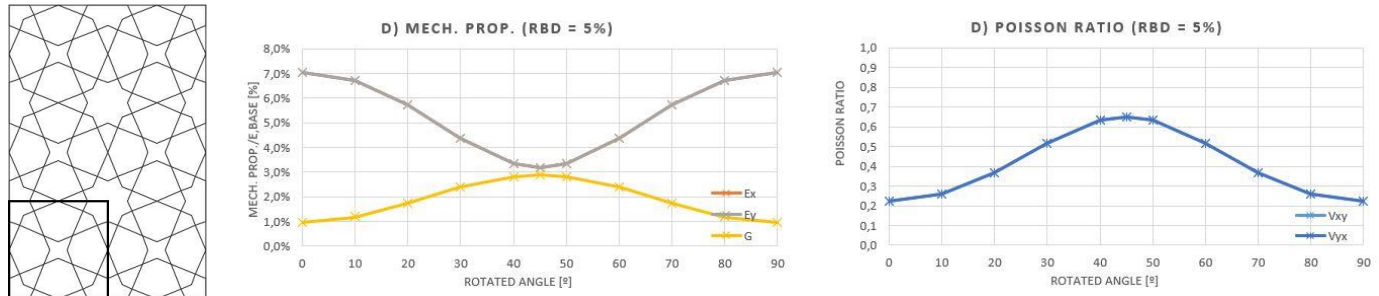


FIG AP1.5.5. Homogenized mechanical properties pattern D, for different pattern orientations.

2%						5%						8%					
ROTATION FACTORS						ROTATION FACTORS						ROTATION FACTORS					
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00
10	0.94	0.94	1.24	1.24	1.56	10	0.95	0.95	1.17	1.17	1.23	10	0.96	0.96	1.13	1.13	1.12
20	0.76	0.76	1.96	1.96	2.97	20	0.81	0.81	1.66	1.66	1.82	20	0.86	0.86	1.48	1.48	1.43
30	0.51	0.51	3.01	3.01	4.58	30	0.62	0.62	2.34	2.34	2.50	30	0.73	0.73	1.95	1.95	1.78
40	0.29	0.29	3.88	3.88	5.63	40	0.47	0.47	2.86	2.86	2.93	40	0.63	0.63	2.29	2.29	2.00
45	0.26	0.26	4.01	4.01	5.78	45	0.45	0.45	2.94	2.94	2.99	45	0.61	0.61	2.34	2.34	2.03
50	0.29	0.29	3.88	3.88	5.63	50	0.47	0.47	2.86	2.86	2.93	50	0.63	0.63	2.29	2.29	2.00
60	0.51	0.51	3.01	3.01	4.58	60	0.62	0.62	2.34	2.34	2.50	60	0.73	0.73	1.95	1.95	1.78
70	0.76	0.76	1.96	1.96	2.97	70	0.81	0.81	1.66	1.66	1.82	70	0.86	0.86	1.48	1.48	1.43
80	0.94	0.94	1.24	1.24	1.56	80	0.95	0.95	1.17	1.17	1.23	80	0.96	0.96	1.13	1.13	1.12
90	1.00	1.00	1.00	1.00	1.00	90	1.00	1.00	1.00	1.00	1.00	90	1.00	1.00	1.00	1.00	1.00

TABLE AP1.5.5. Rotation factors pattern D, for different pattern orientations and saturations of 2%, 5% and 8%

E) PALACE OF THE SHIRVANSHAHS. Tessellation 4.8.8. $\theta = 45^\circ$, with number of crossings = 0

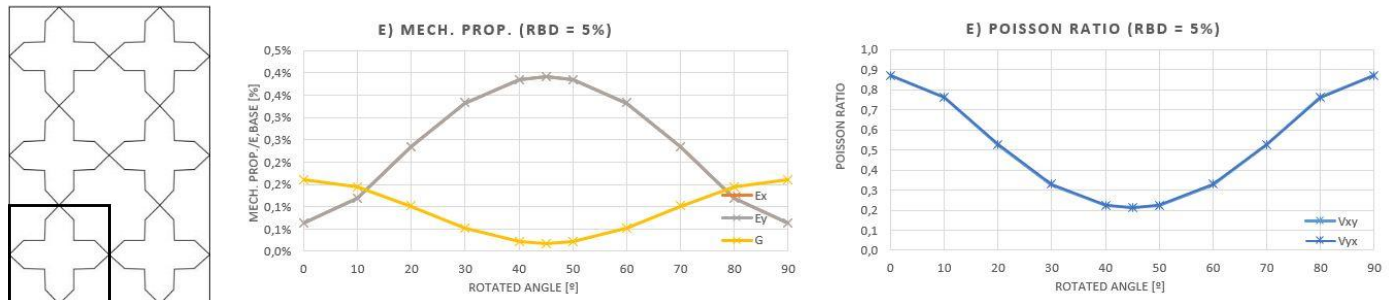


FIG AP1.5.6. Homogenized mechanical properties pattern E, for different pattern orientations.

2%						5%						8%					
ROTATION FACTORS						ROTATION FACTORS						ROTATION FACTORS					
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00
10	1.94	1.94	0.88	0.88	0.89	10	1.88	1.88	0.87	0.87	0.90	10	1.78	1.78	0.86	0.86	0.90
20	3.89	3.89	0.62	0.62	0.63	20	3.69	3.69	0.61	0.61	0.63	20	3.38	3.38	0.59	0.59	0.63
30	5.57	5.57	0.39	0.39	0.32	30	5.24	5.24	0.38	0.38	0.33	30	4.75	4.75	0.35	0.35	0.34
40	6.46	6.46	0.28	0.28	0.13	40	6.06	6.06	0.26	0.26	0.13	40	5.45	5.45	0.23	0.23	0.14
45	6.57	6.57	0.26	0.26	0.10	45	6.16	6.16	0.24	0.24	0.11	45	5.54	5.54	0.21	0.21	0.12
50	6.46	6.46	0.28	0.28	0.13	50	6.06	6.06	0.26	0.26	0.13	50	5.45	5.45	0.23	0.23	0.14
60	5.57	5.57	0.39	0.39	0.32	60	5.24	5.24	0.38	0.38	0.33	60	4.75	4.75	0.35	0.35	0.34
70	3.89	3.89	0.62	0.62	0.63	70	3.69	3.69	0.61	0.61	0.63	70	3.38	3.38	0.59	0.59	0.63
80	1.94	1.94	0.88	0.88	0.89	80	1.88	1.88	0.87	0.87	0.90	80	1.78	1.78	0.86	0.86	0.90
90	1.00	1.00	1.00	1.00	1.00	90	1.00	1.00	1.00	1.00	1.00	90	1.00	1.00	1.00	1.00	1.00

TABLE AP1.5.6. Rotation factors pattern E, for different pattern orientations and saturations of 2%, 5% and 8%

F) MUSTANSIRIYA MADRASA. Tessellation 3.6.3.6. $\theta = 30^\circ$

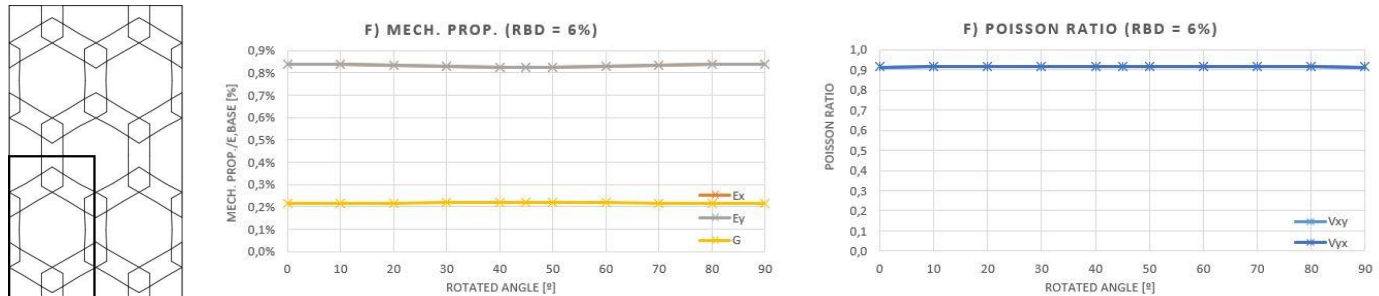


FIG AP1.5.7. Homogenized mechanical properties pattern F, for different pattern orientations.

2%						6%						10%					
ROTATION FACTORS						ROTATION FACTORS						ROTATION FACTORS					
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	10	1.00	1.00	1.00	1.00	1.00	10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00	20	1.00	1.00	1.00	1.00	1.00	20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00	30	1.00	1.00	1.00	1.00	1.00	30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00	40	1.00	1.00	1.00	1.00	1.00	40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00	45	1.00	1.00	1.00	1.00	1.00	45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00	50	1.00	1.00	1.00	1.00	1.00	50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00	60	1.00	1.00	1.00	1.00	1.00	60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00	70	1.00	1.00	1.00	1.00	1.00	70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00	80	1.00	1.00	1.00	1.00	1.00	80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00	90	1.00	1.00	1.00	1.00	1.00	90	1.00	1.00	1.00	1.00	1.00

TABLE AP1.5.7. Rotation factors pattern F, for different pattern orientations and saturations of 2%, 6% and 10%

G) TOMB OF SALIM CHISHTI. Tessellation 6.6.6. $D = 65\%$, $\theta = 75^\circ$

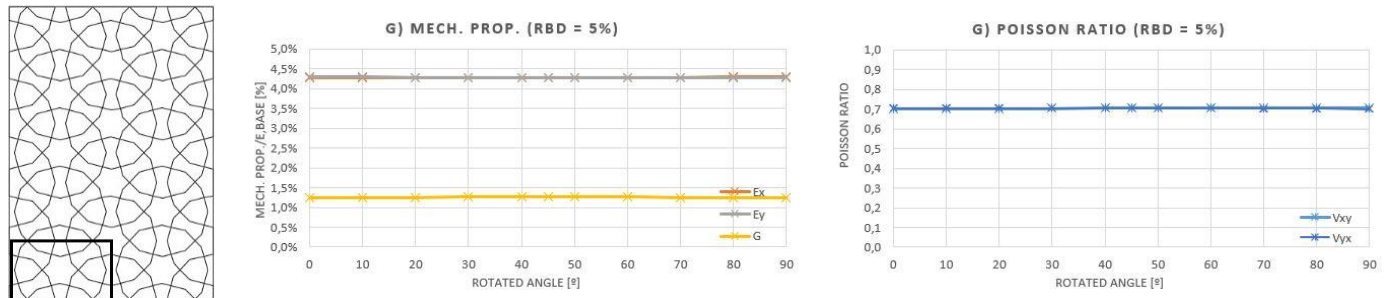


FIG AP1.5.8. Homogenized mechanical properties pattern G, for different pattern orientations.

2%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

5%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

8%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

TABLE AP1.5.8. Rotation factors pattern G, for different pattern orientations and saturations of 2%, 5% and 8%

H) GENERALIFE. Tessellation 3.12.12. $\theta = 60^\circ$

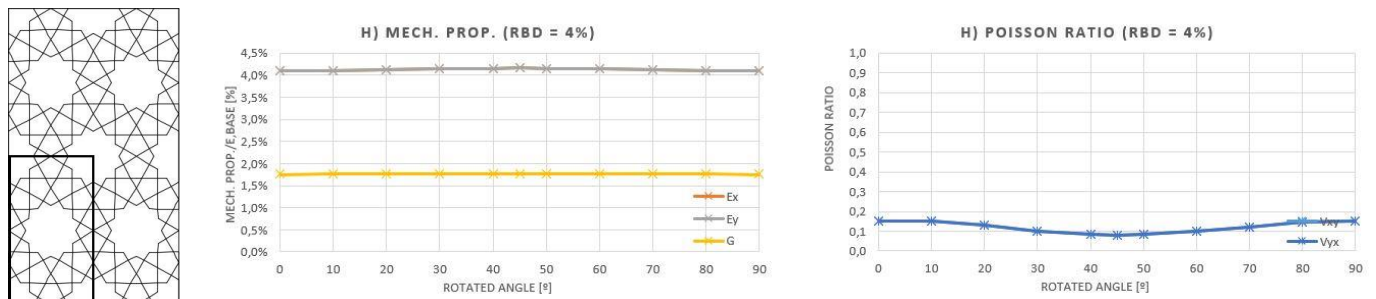


FIG AP1.5.9. Homogenized mechanical properties pattern H, for different pattern orientations.

2%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	0.85	0.85	1.00
30	1.01	1.01	0.67	0.67	1.00
40	1.01	1.01	0.55	0.55	1.00
45	1.01	1.01	0.53	0.53	1.00
50	1.01	1.01	0.54	0.54	1.00
60	1.01	1.01	0.64	0.64	1.00
70	1.01	1.01	0.80	0.80	1.00
80	1.00	1.00	0.94	0.94	1.00
90	1.00	1.00	1.00	1.00	1.00

4%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.01	1.01	0.85	0.85	1.00
30	1.01	1.01	0.67	0.67	1.00
40	1.02	1.02	0.55	0.55	1.00
45	1.02	1.02	0.53	0.53	1.00
50	1.02	1.02	0.54	0.54	1.00
60	1.01	1.01	0.64	0.64	1.00
70	1.01	1.01	0.80	0.80	1.00
80	1.00	1.00	0.94	0.94	1.00
90	1.00	1.00	1.00	1.00	1.00

6%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.01	1.01	0.85	0.85	1.00
30	1.02	1.02	0.67	0.67	1.00
40	1.02	1.02	0.55	0.55	1.00
45	1.02	1.02	0.53	0.53	1.00
50	1.02	1.02	0.54	0.54	1.00
60	1.02	1.02	0.64	0.64	1.00
70	1.01	1.01	0.80	0.80	1.00
80	1.00	1.00	0.94	0.94	1.00
90	1.00	1.00	1.00	1.00	1.00

TABLE AP1.5.9. Rotation factors pattern H, for different pattern orientations and saturations of 2%, 4% and 6%

I) HASHT BEHESHT. Tessellation I-6.10.10. $\theta = 54^\circ$

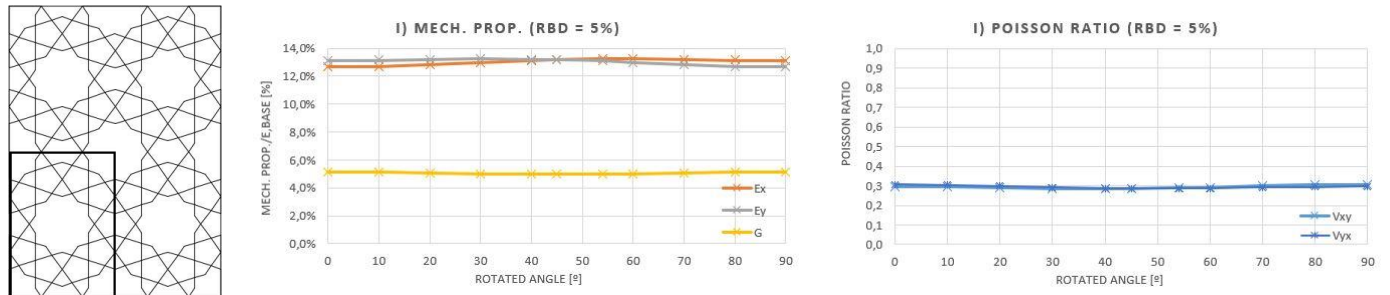


FIG AP1.5.10. Homogenized mechanical properties pattern I, for different pattern orientations.

2%						5%						8%					
ROTATION FACTORS						ROTATION FACTORS						ROTATION FACTORS					
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	0.99	1.00	10	1.00	1.00	1.00	0.99	1.00	10	1.00	1.00	0.99	0.99	1.00
20	1.02	0.99	1.01	0.98	1.00	20	1.01	1.00	0.99	0.97	0.99	20	1.01	1.01	0.98	0.97	0.98
30	1.04	0.97	1.02	0.96	1.00	30	1.03	1.00	0.98	0.95	0.98	30	1.02	1.01	0.96	0.95	0.97
40	1.06	0.95	1.04	0.94	0.99	40	1.04	1.00	0.97	0.93	0.97	40	1.03	1.01	0.95	0.94	0.96
45	1.07	0.94	1.05	0.93	0.99	45	1.05	1.00	0.98	0.93	0.97	45	1.03	1.01	0.95	0.93	0.96
50	1.08	0.93	1.07	0.92	0.99	50	1.05	0.99	0.98	0.93	0.97	50	1.04	1.01	0.95	0.93	0.96
60	1.10	0.91	1.09	0.90	1.00	60	1.05	0.98	1.00	0.93	0.98	60	1.03	1.00	0.97	0.94	0.97
70	1.12	0.90	1.11	0.89	1.00	70	1.05	0.97	1.02	0.94	0.99	70	1.03	0.99	0.99	0.96	0.98
80	1.13	0.88	1.13	0.88	1.00	80	1.05	0.96	1.04	0.95	1.00	80	1.02	0.98	1.01	0.97	1.00
90	1.14	0.88	1.14	0.88	1.00	90	1.05	0.95	1.05	0.95	1.00	90	1.02	0.98	1.02	0.98	1.00

TABLE AP1.5.10. Rotation factors pattern I, for different pattern orientations and saturations of 2%, 5% and 8%

J) MODARI-KHAN MADRASH. Tessellation ROS-I-6.10.10. $\theta_1 = 45^\circ$, $\theta_2 = 60^\circ$. type Star

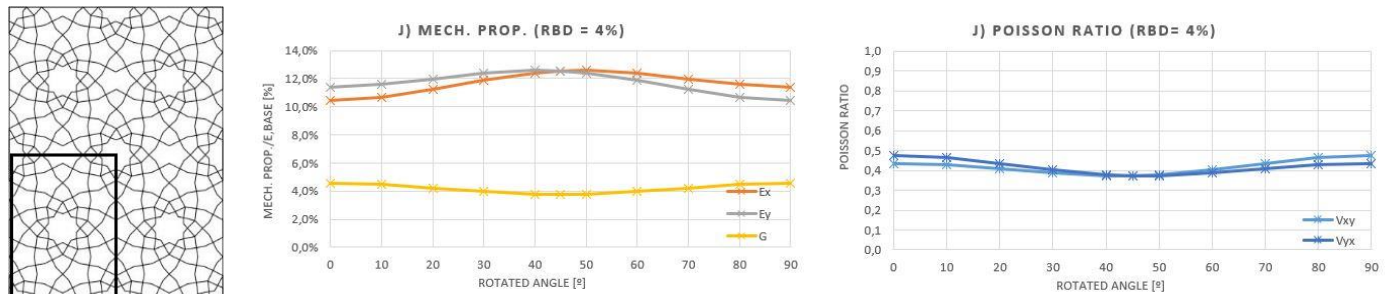


FIG AP1.5.11. Homogenized mechanical properties pattern J, for different pattern orientations.

2%						4%						6%					
ROTATION FACTORS						ROTATION FACTORS						ROTATION FACTORS					
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00
10	1.05	1.03	0.98	0.97	0.97	10	1.02	1.02	0.98	0.98	0.98	10	1.01	1.01	0.98	0.98	0.99
20	1.17	1.11	0.95	0.90	0.88	20	1.08	1.05	0.93	0.91	0.93	20	1.04	1.03	0.94	0.93	0.95
30	1.32	1.18	0.91	0.82	0.79	30	1.14	1.09	0.88	0.84	0.87	30	1.08	1.06	0.89	0.87	0.91
40	1.43	1.20	0.90	0.76	0.72	40	1.19	1.10	0.86	0.80	0.83	40	1.10	1.07	0.86	0.83	0.88
45	1.47	1.19	0.91	0.74	0.71	45	1.20	1.10	0.86	0.79	0.82	45	1.11	1.07	0.86	0.83	0.88
50	1.48	1.16	0.93	0.73	0.72	50	1.21	1.09	0.87	0.79	0.83	50	1.11	1.06	0.87	0.83	0.88
60	1.45	1.07	1.01	0.74	0.79	60	1.19	1.04	0.92	0.81	0.87	60	1.10	1.04	0.91	0.86	0.91
70	1.37	0.95	1.11	0.77	0.88	70	1.15	0.98	1.00	0.86	0.93	70	1.07	1.00	0.96	0.90	0.95
80	1.27	0.85	1.20	0.80	0.97	80	1.11	0.93	1.07	0.90	0.98	80	1.05	0.97	1.02	0.95	0.99
90	1.23	0.81	1.23	0.81	1.00	90	1.09	0.92	1.09	0.92	1.00	90	1.04	0.96	1.04	0.96	1.00

TABLE AP1.5.11. Rotation factors pattern J, for different pattern orientations and saturations of 2%, 4% and 6%

K) COMPLEX OF SULTAN BAYEZID II. Tessellation ROS-3.4.3.12.3.12.12. $\theta = 60^\circ$, type Bayezid

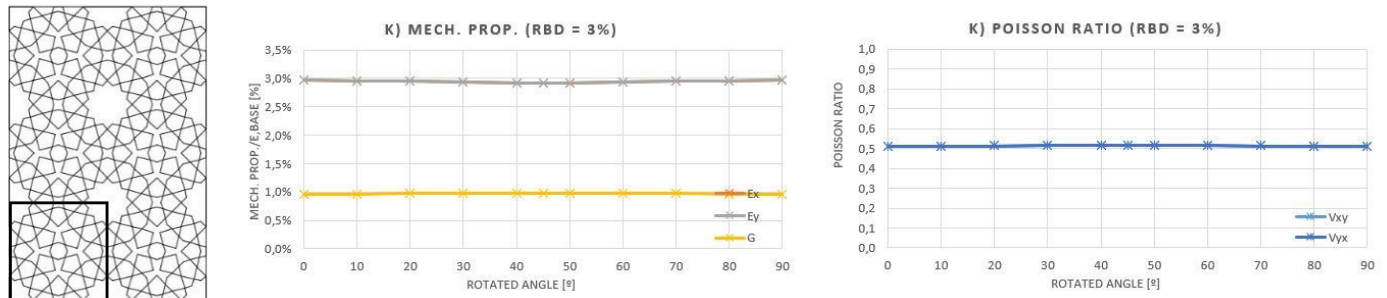


FIG AP1.5.12. Homogenized mechanical properties pattern K, for different pattern orientations.

1.5%						3%						4.5%					
ROTATION FACTORS						ROTATION FACTORS						ROTATION FACTORS					
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00
10	0.98	0.98	1.01	1.01	1.02	10	1.00	1.00	1.00	1.00	1.00	10	1.01	1.01	0.99	0.99	0.99
20	0.94	0.94	1.04	1.04	1.09	20	0.99	0.99	1.01	1.01	1.01	20	1.02	1.02	0.98	0.98	0.98
30	0.89	0.89	1.07	1.07	1.16	30	0.99	0.99	1.01	1.01	1.02	30	1.03	1.03	0.96	0.96	0.95
40	0.86	0.86	1.09	1.09	1.20	40	0.99	0.99	1.01	1.01	1.02	40	1.04	1.04	0.94	0.94	0.94
45	0.86	0.86	1.09	1.09	1.21	45	0.98	0.98	1.01	1.01	1.02	45	1.05	1.05	0.94	0.94	0.94
50	0.86	0.86	1.09	1.09	1.20	50	0.99	0.99	1.01	1.01	1.02	50	1.04	1.04	0.94	0.94	0.94
60	0.89	0.89	1.07	1.07	1.16	60	0.99	0.99	1.01	1.01	1.02	60	1.03	1.03	0.96	0.96	0.95
70	0.94	0.94	1.04	1.04	1.09	70	0.99	0.99	1.01	1.01	1.01	70	1.02	1.02	0.98	0.98	0.98
80	0.98	0.98	1.01	1.01	1.02	80	1.00	1.00	1.00	1.00	1.00	80	1.01	1.01	0.99	0.99	0.99
90	1.00	1.00	1.00	1.00	1.00	90	1.00	1.00	1.00	1.00	1.00	90	1.00	1.00	1.00	1.00	1.00

TABLE AP1.5.12. Rotation factors pattern K, for different pattern orientations and saturations of 1.5%, 3% and 4.5%

L) BEN YUSUF MADRASA. Tessellation ROS-3.4.3.12.3.12.12. $\theta = 75^\circ$, type Arrow

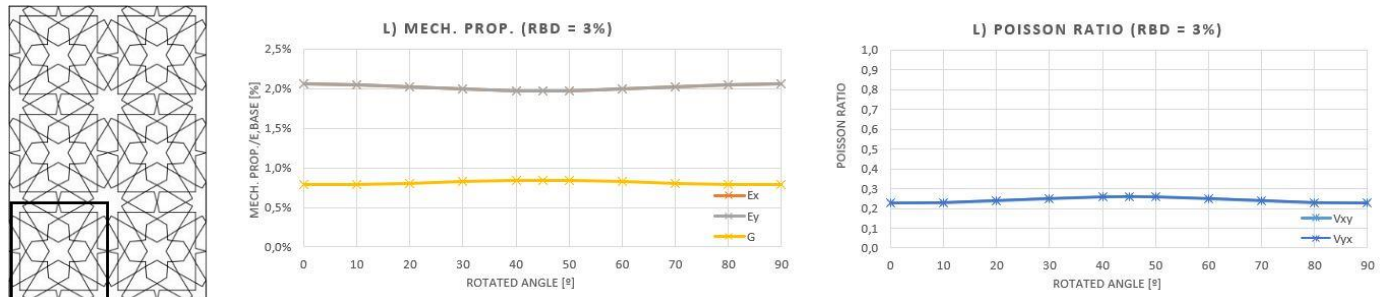


FIG AP1.5.13. Homogenized mechanical properties pattern L, for different pattern orientations.

1%						2.5%						4%					
ROTATION FACTORS						ROTATION FACTORS						ROTATION FACTORS					
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00
10	0.98	0.98	1.07	1.07	1.04	10	0.99	0.99	1.02	1.02	1.01	10	1.00	1.00	1.00	1.00	1.00
20	0.94	0.94	1.26	1.26	1.13	20	0.98	0.98	1.06	1.06	1.03	20	1.00	1.00	1.00	1.00	1.00
30	0.88	0.88	1.48	1.48	1.24	30	0.97	0.97	1.11	1.11	1.06	30	1.00	1.00	1.00	1.00	1.00
40	0.85	0.85	1.64	1.64	1.31	40	0.96	0.96	1.15	1.15	1.07	40	1.00	1.00	1.01	1.01	1.00
45	0.84	0.84	1.66	1.66	1.32	45	0.96	0.96	1.15	1.15	1.07	45	1.00	1.00	1.01	1.01	1.00
50	0.85	0.85	1.64	1.64	1.31	50	0.96	0.96	1.15	1.15	1.07	50	1.00	1.00	1.01	1.01	1.00
60	0.88	0.88	1.48	1.48	1.24	60	0.97	0.97	1.11	1.11	1.06	60	1.00	1.00	1.00	1.00	1.00
70	0.94	0.94	1.26	1.26	1.13	70	0.98	0.98	1.06	1.06	1.03	70	1.00	1.00	1.00	1.00	1.00
80	0.98	0.98	1.07	1.07	1.04	80	0.99	0.99	1.02	1.02	1.01	80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00	90	1.00	1.00	1.00	1.00	1.00	90	1.00	1.00	1.00	1.00	1.00

TABLE AP1.5.13. Rotation factors pattern L, for different pattern orientations and saturations of 1%, 2.5% and 4%

M) AL-NASIR MUHAMMAD'S MINBAR. Tessellation ROS-I-6.12.8.12. $\theta = 75^\circ$, L = 20%, type Arrow

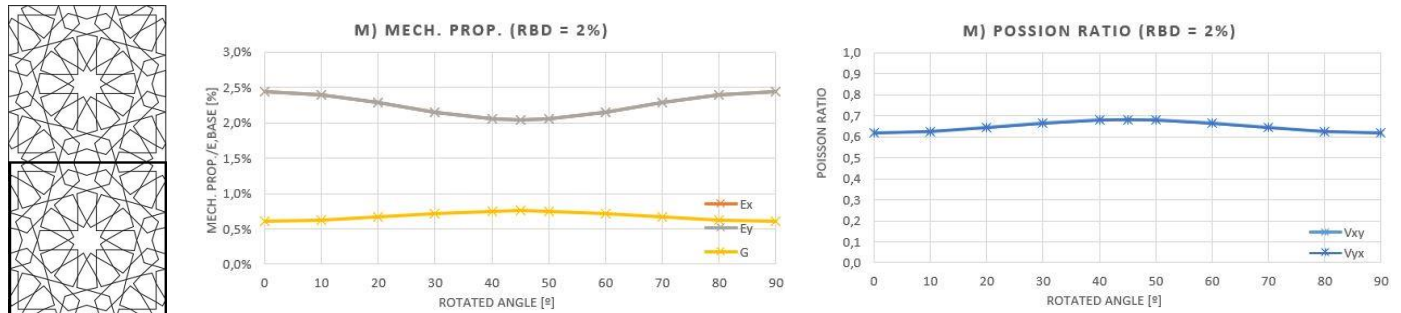


FIG AP1.5.14. Homogenized mechanical properties pattern M, for different pattern orientations.

1%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	0.98	0.98	1.01	1.01	1.03
20	0.93	0.93	1.03	1.03	1.11
30	0.86	0.86	1.05	1.05	1.19
40	0.82	0.82	1.07	1.07	1.25
45	0.82	0.82	1.07	1.07	1.26
50	0.82	0.82	1.07	1.07	1.25
60	0.86	0.86	1.05	1.05	1.19
70	0.93	0.93	1.03	1.03	1.11
80	0.98	0.98	1.01	1.01	1.03
90	1.00	1.00	1.00	1.00	1.00

2%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	0.98	0.98	1.01	1.01	1.03
20	0.93	0.93	1.04	1.04	1.10
30	0.88	0.88	1.08	1.08	1.18
40	0.84	0.84	1.10	1.10	1.23
45	0.84	0.84	1.10	1.10	1.24
50	0.84	0.84	1.10	1.10	1.23
60	0.88	0.88	1.08	1.08	1.18
70	0.93	0.93	1.04	1.04	1.10
80	0.98	0.98	1.01	1.01	1.03
90	1.00	1.00	1.00	1.00	1.00

3%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	0.98	0.98	1.01	1.01	1.03
20	0.94	0.94	1.05	1.05	1.09
30	0.90	0.90	1.10	1.10	1.16
40	0.86	0.86	1.13	1.13	1.21
45	0.86	0.86	1.13	1.13	1.21
50	0.86	0.86	1.13	1.13	1.21
60	0.90	0.90	1.10	1.10	1.16
70	0.94	0.94	1.05	1.05	1.09
80	0.98	0.98	1.01	1.01	1.03
90	1.00	1.00	1.00	1.00	1.00

TABLE AP1.5.14. Rotation factors pattern M, for different pattern orientations and saturations of 1%, 2% and 3%

N) MOSQUE OF AL-NASIR MUHAMMAD. Tessellation ROS-3.12.12. $\theta = 75^\circ$, type Arrow

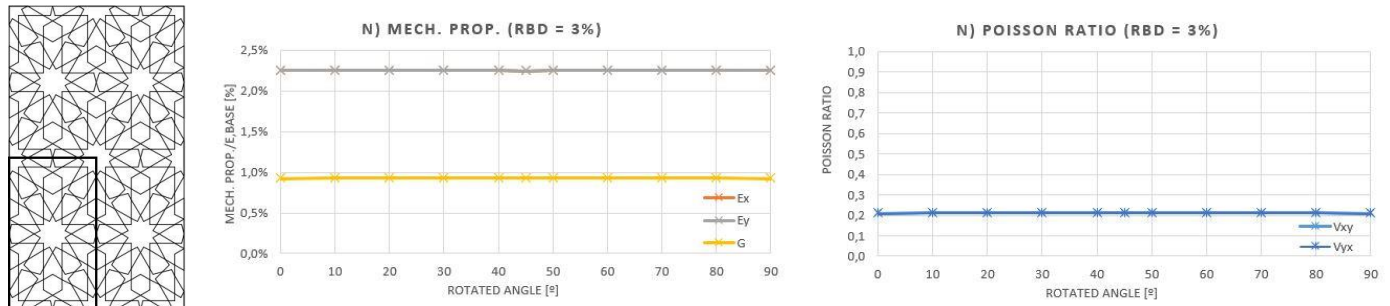


FIG AP1.5.15. Homogenized mechanical properties pattern N, for different pattern orientations.

1.5%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

3%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

4.5%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

TABLE AP1.5.15. Rotation factors pattern N, for different pattern orientations and saturations of 1.5%, 3% and 4.5%

O) GREAT MOSQUE OF HERAT. Tessellation ROS-4.8.8. $\theta = 70^\circ$, $L = 30\%$

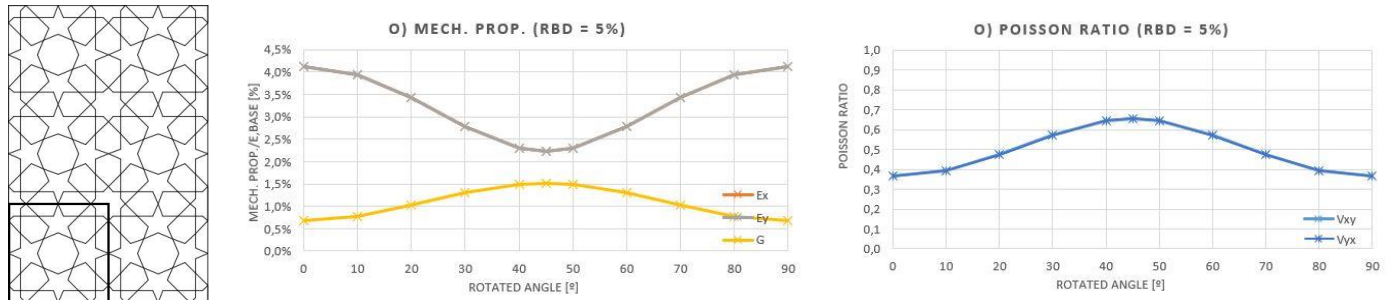


FIG AP1.5.16. Homogenized mechanical properties pattern O, for different pattern orientations.

2%						5%						8%					
ROTATION FACTORS						ROTATION FACTORS						ROTATION FACTORS					
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00
10	0.95	0.95	1.08	1.08	1.22	10	0.96	0.96	1.08	1.08	1.14	10	0.96	0.96	1.08	1.08	1.10
20	0.80	0.80	1.30	1.30	1.76	20	0.83	0.83	1.29	1.29	1.51	20	0.87	0.87	1.30	1.30	1.35
30	0.60	0.60	1.58	1.58	2.38	30	0.67	0.67	1.56	1.56	1.92	30	0.75	0.75	1.58	1.58	1.64
40	0.46	0.46	1.78	1.78	2.79	40	0.56	0.56	1.76	1.76	2.19	40	0.66	0.66	1.78	1.78	1.82
45	0.43	0.43	1.82	1.82	2.84	45	0.54	0.54	1.79	1.79	2.23	45	0.64	0.64	1.81	1.81	1.85
50	0.46	0.46	1.78	1.78	2.79	50	0.56	0.56	1.76	1.76	2.19	50	0.66	0.66	1.78	1.78	1.82
60	0.60	0.60	1.58	1.58	2.38	60	0.67	0.67	1.56	1.56	1.92	60	0.75	0.75	1.58	1.58	1.64
70	0.80	0.80	1.30	1.30	1.76	70	0.83	0.83	1.29	1.29	1.51	70	0.87	0.87	1.30	1.30	1.35
80	0.95	0.95	1.08	1.08	1.22	80	0.96	0.96	1.08	1.08	1.14	80	0.96	0.96	1.08	1.08	1.10
90	1.00	1.00	1.00	1.00	1.00	90	1.00	1.00	1.00	1.00	1.00	90	1.00	1.00	1.00	1.00	1.00

TABLE AP1.5.16. Rotation factors pattern O, for different pattern orientations and saturations of 2%, 5% and 8%

P) MOSQUE OF AL-SALIH TALA'I Tessellation ROS-3.4.3.8.3.8.8. $\theta = 75^\circ$, $L = 25\%$, type Star

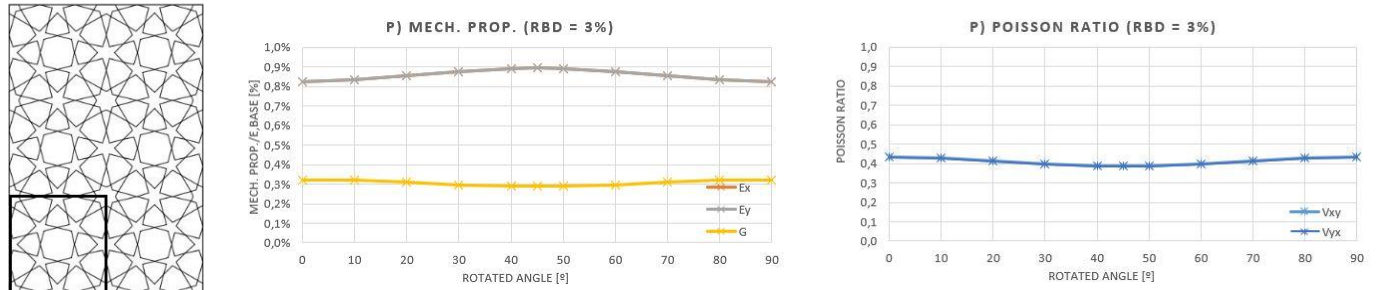


FIG AP1.5.17. Homogenized mechanical properties pattern P, for different pattern orientations.

1%						3%						5%					
ROTATION FACTORS						ROTATION FACTORS						ROTATION FACTORS					
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}	Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00
10	1.01	1.01	0.99	0.99	0.99	10	1.01	1.01	0.99	0.99	0.99	10	1.01	1.01	0.98	0.98	0.99
20	1.04	1.04	0.96	0.96	0.96	20	1.04	1.04	0.95	0.95	0.96	20	1.03	1.03	0.95	0.95	0.96
30	1.06	1.06	0.93	0.93	0.92	30	1.06	1.06	0.92	0.92	0.92	30	1.06	1.06	0.90	0.90	0.92
40	1.08	1.08	0.91	0.91	0.90	40	1.08	1.08	0.89	0.89	0.89	40	1.08	1.08	0.88	0.88	0.90
45	1.08	1.08	0.90	0.90	0.89	45	1.08	1.08	0.89	0.89	0.89	45	1.08	1.08	0.87	0.87	0.89
50	1.08	1.08	0.91	0.91	0.90	50	1.08	1.08	0.89	0.89	0.89	50	1.08	1.08	0.88	0.88	0.90
60	1.06	1.06	0.93	0.93	0.92	60	1.06	1.06	0.92	0.92	0.92	60	1.06	1.06	0.90	0.90	0.92
70	1.04	1.04	0.96	0.96	0.96	70	1.04	1.04	0.95	0.95	0.96	70	1.03	1.03	0.95	0.95	0.96
80	1.01	1.01	0.99	0.99	0.99	80	1.01	1.01	0.99	0.99	0.99	80	1.01	1.01	0.98	0.98	0.99
90	1.00	1.00	1.00	1.00	1.00	90	1.00	1.00	1.00	1.00	1.00	90	1.00	1.00	1.00	1.00	1.00

TABLE AP1.5.17. Rotation factors pattern P, for different pattern orientations and saturations of 1%, 3% and 5%

Q) MOSQUE OF IBN TULUN. Tessellation ROS-3.4.3.12.3.12.12. $\theta_1 = 75^\circ$, $\theta_2 = 65^\circ$, type Star

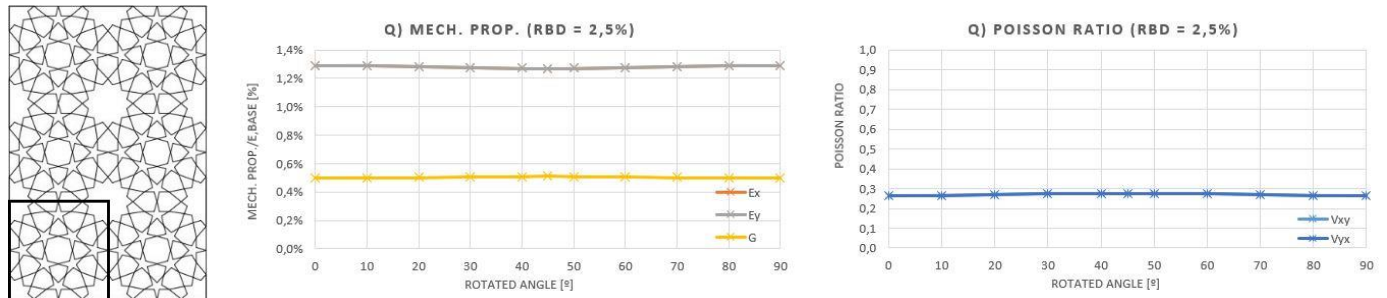


FIG AP1.5.18. Homogenized mechanical properties pattern Q, for different pattern orientations.

1%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	0.99	0.99	1.02	1.02	1.01
20	0.97	0.97	1.08	1.08	1.05
30	0.95	0.95	1.14	1.14	1.08
40	0.94	0.94	1.18	1.18	1.11
45	0.94	0.94	1.19	1.19	1.11
50	0.94	0.94	1.18	1.18	1.11
60	0.95	0.95	1.14	1.14	1.08
70	0.97	0.97	1.08	1.08	1.05
80	0.99	0.99	1.02	1.02	1.01
90	1.00	1.00	1.00	1.00	1.00

2.5%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	0.99	0.99	1.02	1.02	1.01
30	0.99	0.99	1.03	1.03	1.02
40	0.99	0.99	1.04	1.04	1.02
45	0.99	0.99	1.04	1.04	1.02
50	0.99	0.99	1.04	1.04	1.02
60	0.99	0.99	1.03	1.03	1.02
70	0.99	0.99	1.02	1.02	1.01
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

4%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	0.99	0.99	1.00
20	1.01	1.01	0.97	0.97	0.98
30	1.02	1.02	0.94	0.94	0.97
40	1.03	1.03	0.92	0.92	0.96
45	1.03	1.03	0.92	0.92	0.96
50	1.03	1.03	0.92	0.92	0.96
60	1.02	1.02	0.94	0.94	0.97
70	1.01	1.01	0.97	0.97	0.98
80	1.00	1.00	0.99	0.99	1.00
90	1.00	1.00	1.00	1.00	1.00

TABLE AP1.5.18. Rotation factors pattern Q, for different pattern orientations and saturations of 1%, 2.5% and 4%

R) FATEHPUR SIKRI. Tessellation ROS-I-6.10.10. $\theta = 72^\circ$ type Star

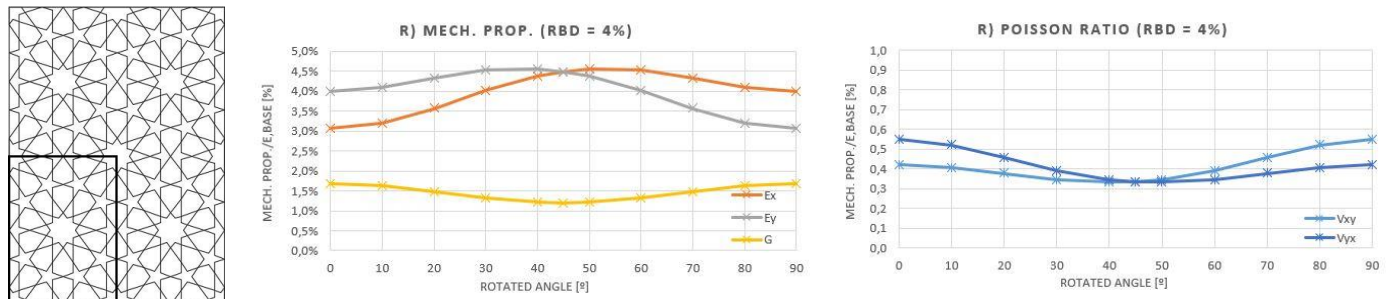


FIG AP1.5.19. Homogenized mechanical properties pattern R, for different pattern orientations.

2%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.07	1.05	0.97	0.95	0.96
20	1.25	1.15	0.90	0.82	0.85
30	1.47	1.23	0.82	0.69	0.72
40	1.65	1.25	0.79	0.60	0.64
45	1.70	1.23	0.80	0.58	0.63
50	1.73	1.19	0.83	0.57	0.64
60	1.70	1.07	0.95	0.60	0.72
70	1.58	0.91	1.13	0.65	0.85
80	1.44	0.78	1.31	0.70	0.96
90	1.38	0.72	1.38	0.72	1.00

4%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.05	1.03	0.97	0.95	0.97
20	1.17	1.09	0.90	0.84	0.88
30	1.31	1.14	0.82	0.71	0.79
40	1.43	1.14	0.79	0.63	0.72
45	1.47	1.13	0.80	0.61	0.71
50	1.49	1.10	0.82	0.61	0.72
60	1.48	1.00	0.93	0.63	0.79
70	1.42	0.89	1.09	0.69	0.88
80	1.34	0.80	1.24	0.74	0.97
90	1.30	0.77	1.30	0.77	1.00

6%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.03	1.02	0.97	0.95	0.97
20	1.12	1.05	0.90	0.85	0.91
30	1.22	1.08	0.82	0.73	0.83
40	1.30	1.08	0.78	0.65	0.78
45	1.33	1.07	0.78	0.63	0.78
50	1.35	1.05	0.81	0.63	0.78
60	1.35	0.98	0.91	0.66	0.83
70	1.31	0.90	1.05	0.72	0.91
80	1.27	0.83	1.19	0.78	0.97
90	1.25	0.80	1.25	0.80	1.00

TABLE AP1.5.19. Rotation factors pattern R, for different pattern orientations and saturations of 2%, 4% and 6%

S) JAMEH MOSQUE. Tessellation ROS-I-6.12.8.12. $\theta = 70^\circ$, $L = 20\%$, Type Star

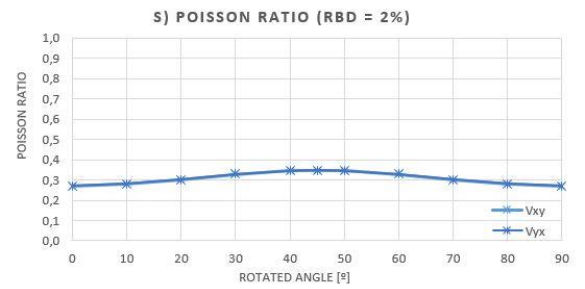
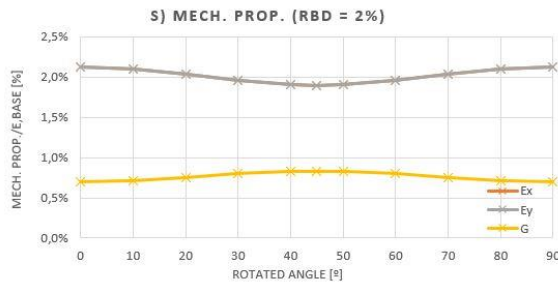
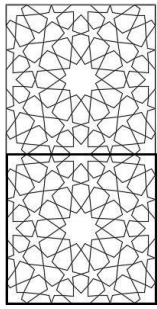


FIG AP1.5.20. Homogenized mechanical properties pattern S, for different pattern orientations.

1%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	0.99	0.99	1.02	1.02	1.01
20	0.97	0.97	1.06	1.06	1.05
30	0.95	0.95	1.11	1.11	1.09
40	0.93	0.93	1.14	1.14	1.11
45	0.93	0.93	1.15	1.15	1.12
50	0.93	0.93	1.14	1.14	1.11
60	0.95	0.95	1.11	1.11	1.09
70	0.97	0.97	1.06	1.06	1.05
80	0.99	0.99	1.02	1.02	1.01
90	1.00	1.00	1.00	1.00	1.00

2%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	0.99	0.99	1.03	1.03	1.02
20	0.96	0.96	1.11	1.11	1.08
30	0.92	0.92	1.21	1.21	1.14
40	0.90	0.90	1.27	1.27	1.18
45	0.89	0.89	1.28	1.28	1.19
50	0.90	0.90	1.27	1.27	1.18
60	0.92	0.92	1.21	1.21	1.14
70	0.96	0.96	1.11	1.11	1.08
80	0.99	0.99	1.03	1.03	1.02
90	1.00	1.00	1.00	1.00	1.00

3%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	0.99	0.99	1.05	1.05	1.03
20	0.95	0.95	1.17	1.17	1.09
30	0.91	0.91	1.32	1.32	1.17
40	0.88	0.88	1.42	1.42	1.22
45	0.88	0.88	1.43	1.43	1.22
50	0.88	0.88	1.42	1.42	1.22
60	0.91	0.91	1.32	1.32	1.17
70	0.95	0.95	1.17	1.17	1.09
80	0.99	0.99	1.05	1.05	1.03
90	1.00	1.00	1.00	1.00	1.00

TABLE AP1.5.20. Rotation factors pattern S, for different pattern orientations and saturations of 1%, 2% and 3%

T) ALHAMBRA. Alhambra. Tessellation ROS-I-6.9.12.9. $\theta = 70^\circ$, $L = 35\%$

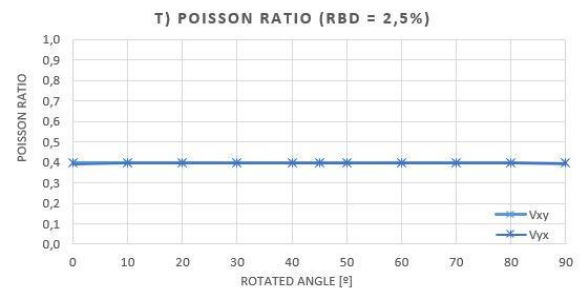
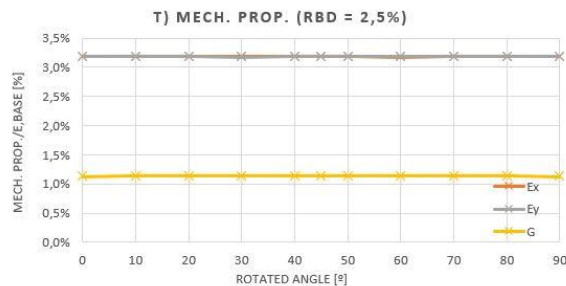
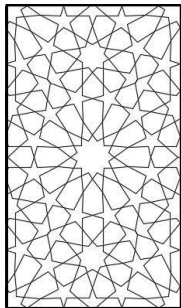


FIG AP1.5.21. Homogenized mechanical properties pattern T, for different pattern orientations.

1%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

2.5%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

4%	ROTATION FACTORS				
Rot [°]	C _{R_EX}	C _{R_EY}	C _{R_VX}	C _{R_VY}	C _{R_G}
0	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00

TABLE AP1.5.21. Rotation factors pattern T, for different pattern orientations and saturations of 1%, 2.5% and 4%

6. STAR FILLING

When there is a sharp turn in the force path, bending moments develop in the internal bars to get equilibrium. As axial stiffness is much bigger than bending stiffness, the most efficient and best performing patterns are those that maximize the ratio between their axial and bending strain energy. From this conclusion, a new set of solutions is proposed. Filling the stars will lead to much more efficient solutions since continuity in the force path is re-established, minimizing the bending strain energy.

It is possible to reach much higher saturation grades filling the stars, however, the pattern blurs very fast as the relative beam depth increases, **limiting the range to very small relative beam depths so the pattern can still be recognized**. For comparison purposes, it is more useful to have the mechanical properties expressed in terms of the saturation. The saturation and the mechanical properties have an exponential evolution. So far, the intermediate values have been obtained by the means of linear interpolation, considering that the results would be accurate enough because the control points were very close to each other. In this chapter however, a more precise and short approach is followed. Instead of providing a large amount of control points, just 3 points are given, so any intermediate value can be accurately calculated by quadratic interpolation.

A*) YESLI MOSQUE

A0*		HOMOG. MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
35	5.97	9.44%	9.44%	0.458	0.458	3.24%
40	9.14	13.17%	13.17%	0.406	0.406	4.69%
45	12.44	17.17%	17.18%	0.365	0.365	6.30%

TABLE AP1.6.1. Homogenized mechanical properties, pattern A*

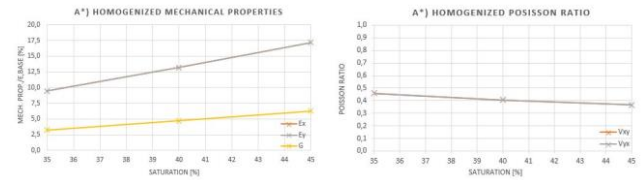


FIG AP1.6.1. Homogenized mechanical properties, pattern A*

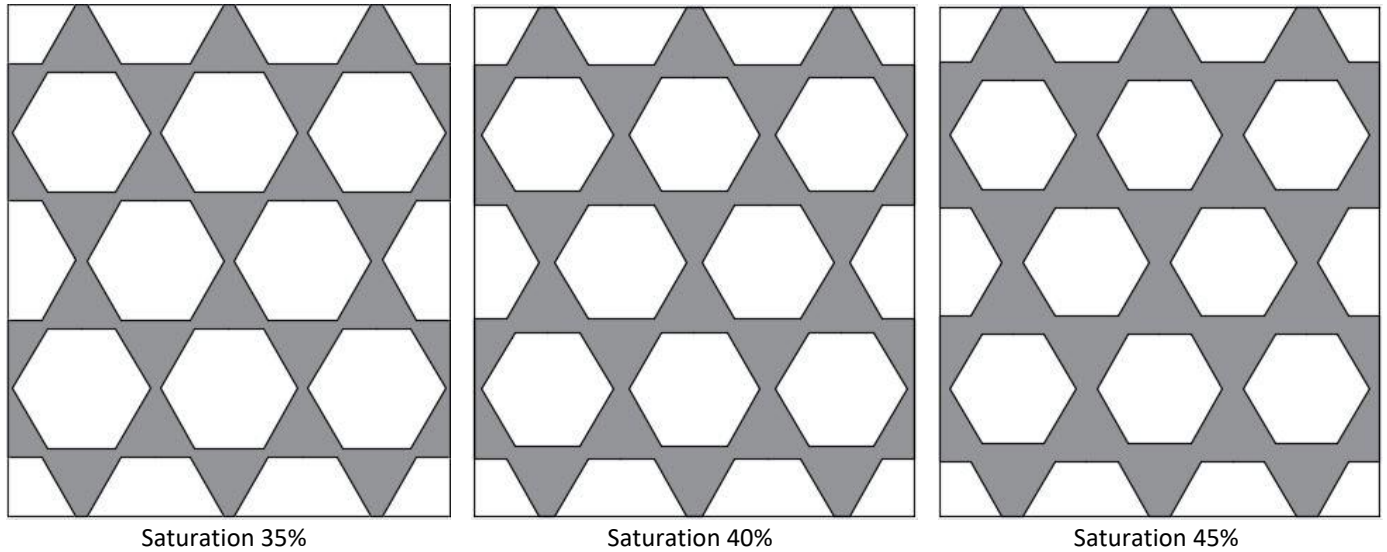


FIG AP1.6.2. Pattern A* for different saturations

B60*) GREAT MOSQUE OF DAMASCUS

B60*		HOMOG. MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
55	1.49	21.08%	21.09%	0.285	0.285	8.24%
60	3.05	27.94%	27.94%	0.277	0.277	10.96%
65	4.72	34.42%	34.45%	0.270	0.270	13.57%

TABLE AP1.6.2. Homogenized mechanical properties, pattern B60*

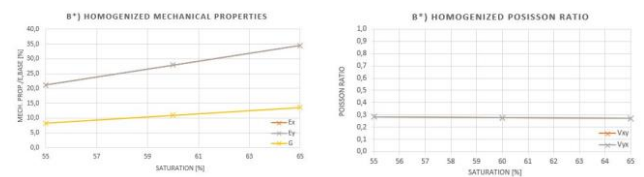
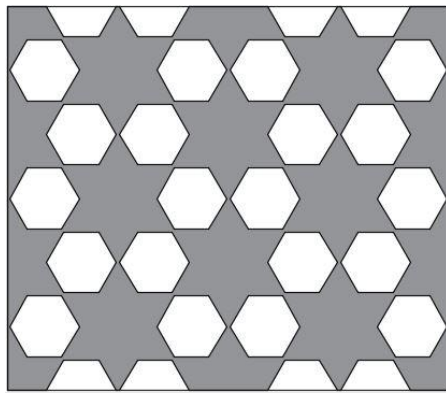
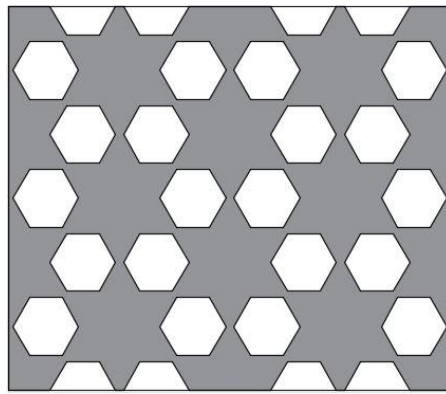


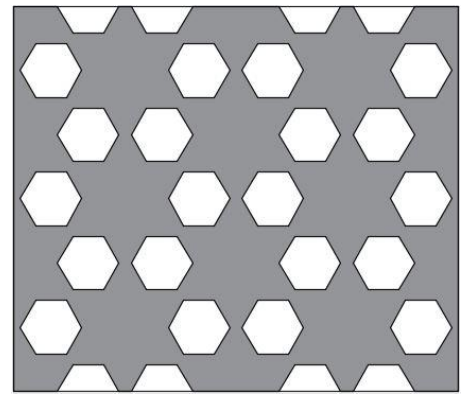
FIG AP1.6.3. Homogenized mechanical properties, pattern B60*



Saturation 55%



Saturation 60%



Saturation 65%

FIG AP1.6.4. Pattern A* for different saturations

B75*) GREAT MOSQUE OF DAMASCUS

B75*		HOMOG. MECHANICAL PROPERTIES				
Sat [%]	rel [%]	E_x	E_y	ν_{xy}	ν_{yx}	G
40	2.02	14.90%	14.90%	0.317	0.317	5.72%
45	3.31	19.01%	18.99%	0.311	0.311	7.30%
50	4.65	23.08%	23.09%	0.303	0.304	8.90%

TABLE AP1.6.3. Homogenized mechanical properties, pattern B75*

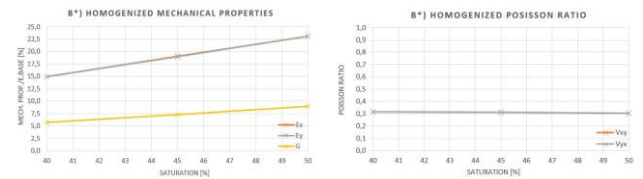
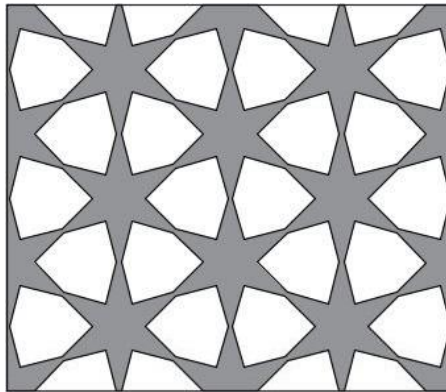
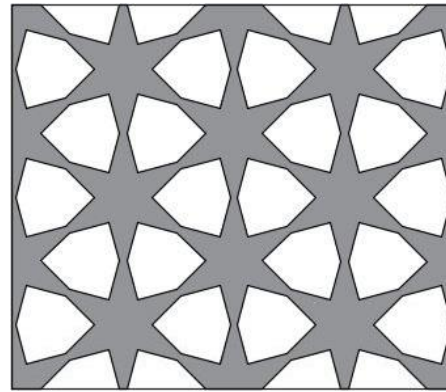


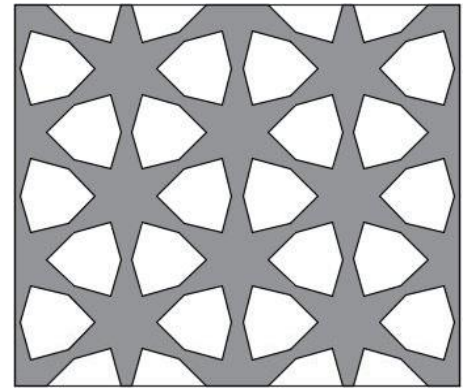
FIG AP1.6.5. Homogenized mechanical properties, pattern B75*



Saturation 40%



Saturation 45%



Saturation 50%

FIG AP1.6.6. Pattern A* for different saturations

D*) LAHORE FORT COMPLEX

D67.5*		HOMOG. MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
35	1.58	5.90%	5.89%	0.589	0.589	2.86%
40	3.02	9.32%	9.32%	0.521	0.521	4.31%
45	4.52	13.08%	13.08%	0.465	0.465	5.92%

TABLE AP1.6.4. Homogenized mechanical properties, pattern D*

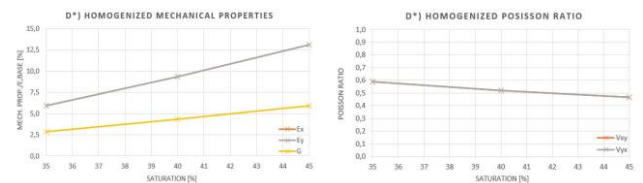
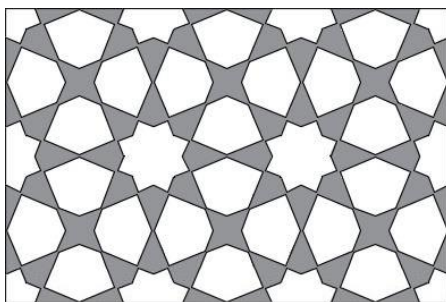
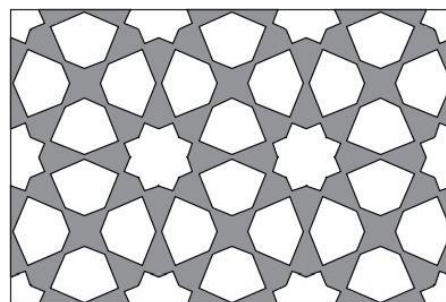


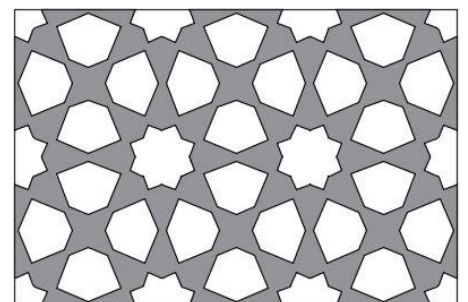
FIG AP1.6.7. Homogenized mechanical properties, pattern D*



Saturation 35%



Saturation 40%



Saturation 45%

FIG AP1.6.8. Pattern A* for different saturations

E*) PALACE OF THE SHIRVANSHAHS

E45*		HOMOG. MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
45	2.20	17.52%	17.52%	0.050	0.050	1.71%
50	5.39	23.34%	23.34%	0.070	0.070	2.61%
55	8.74	28.42%	28.40%	0.090	0.090	3.73%

TABLE AP1.6.5. Homogenized mechanical properties, pattern E*

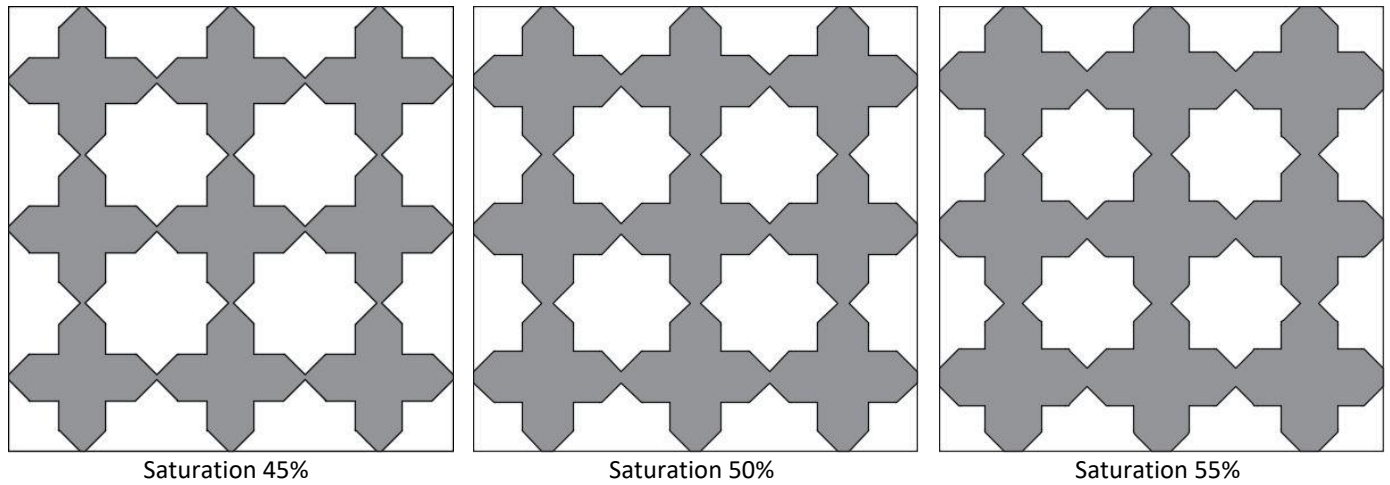
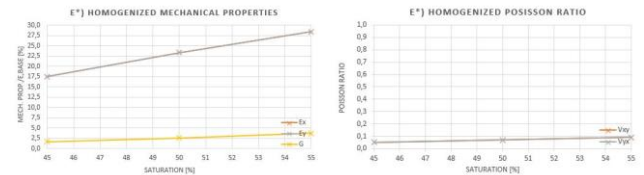


FIG AP1.6.10. Pattern A* for different saturations

F*) MUSTANSIRIYA MADRASA

F30*		HOMOG. MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
35	1.53	9.80%	9.82%	0.349	0.349	3.68%
40	3.66	13.79%	13.79%	0.349	0.349	5.15%
45	5.92	17.45%	17.45%	0.348	0.348	6.50%

TABLE AP1.6.6. Homogenized mechanical properties, pattern F*

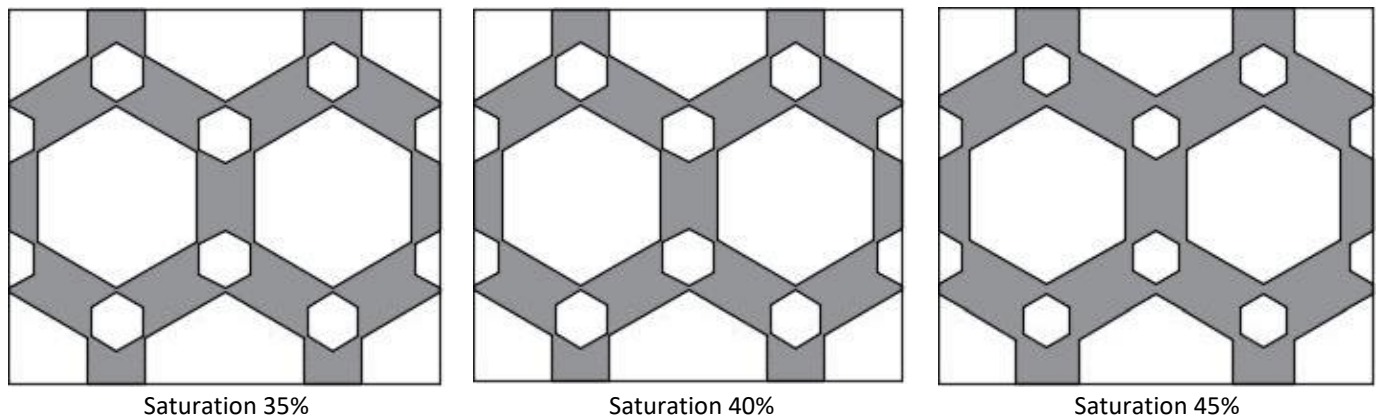
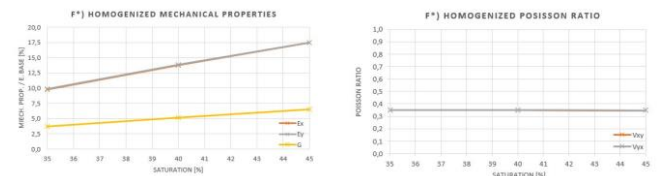
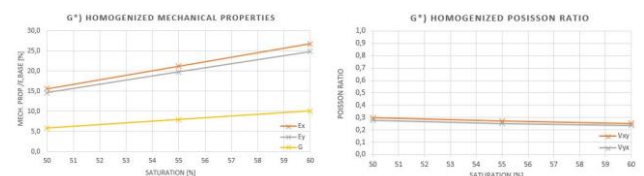


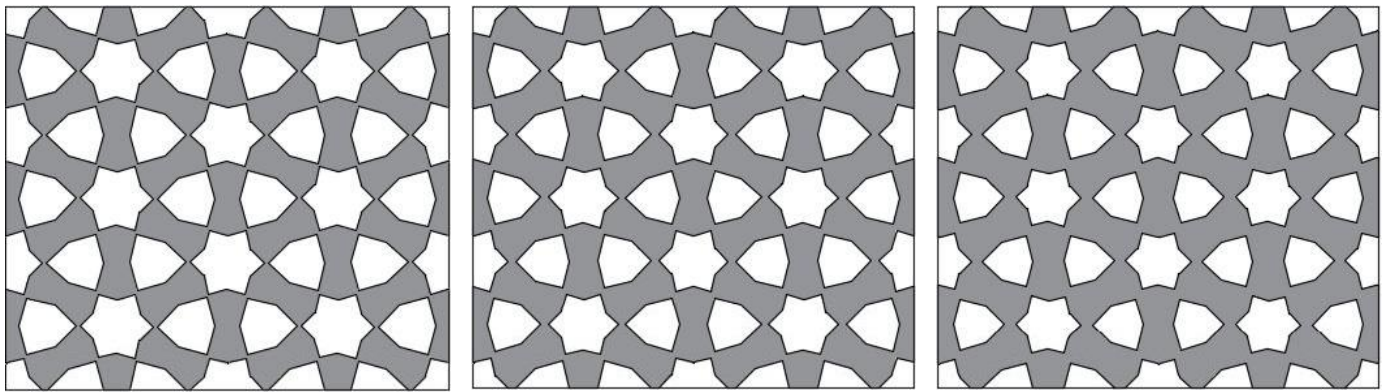
FIG AP1.6.12. Pattern A* for different saturations

G*) TOMB OF SALIM CHISHTI

G75*		HOMOG. MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
50	1.32	15.63%	14.63%	0.298	0.279	5.81%
55	2.45	21.26%	19.78%	0.270	0.251	7.96%
60	3.64	26.75%	24.84%	0.254	0.235	10.06%

TABLE AP1.6.7. Homogenized mechanical properties, pattern G*





Saturation 50%

Saturation 55%

Saturation 60%

FIG AP1.6.14. Pattern A*for different saturations

H*) GENERALIFE

H60*		HOMOG. MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
35	1.48	6.98%	6.97%	0.476	0.476	2.37%
40	2.69	10.37%	10.36%	0.423	0.422	3.64%
45	3.95	13.90%	13.93%	0.384	0.385	5.02%

TABLE AP1.6.8. Homogenized mechanical properties, pattern H*

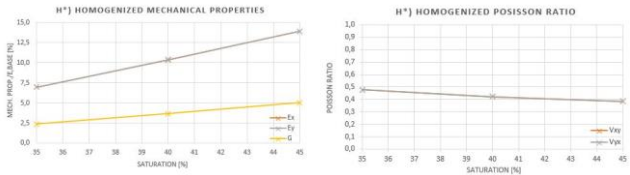
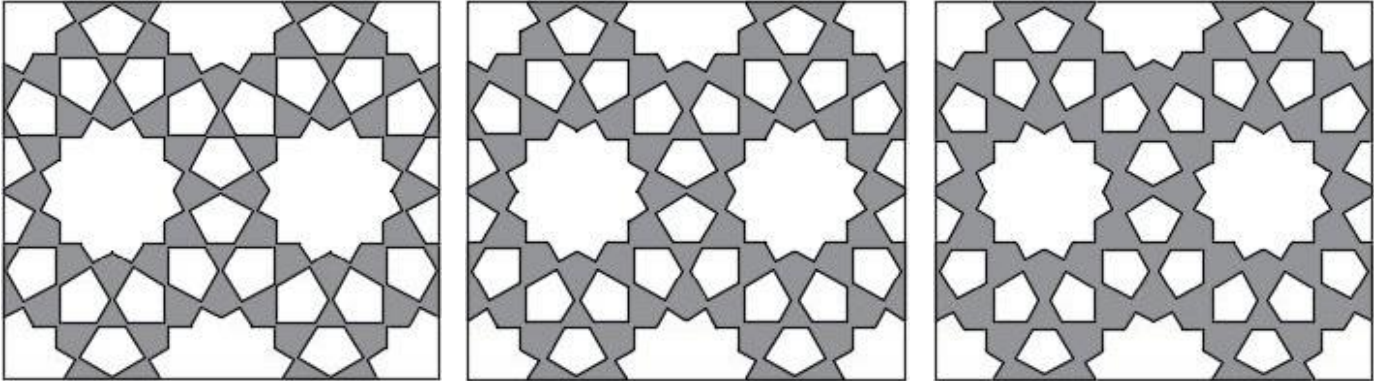


FIG AP1.6.15. Homogenized mechanical properties, pattern H*



Saturation 35%

Saturation 40%

Saturation 45%

FIG AP1.6.16. Pattern A*for different saturations

I*) HASHT BEHESHT

I54*		HOMOG. MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
35	1.79	7.52%	7.74%	0.472	0.486	1.91%
40	2.98	10.88%	11.12%	0.424	0.433	3.36%
45	4.23	14.44%	14.67%	0.389	0.395	4.89%

TABLE AP1.6.9. Homogenized mechanical properties, pattern I*

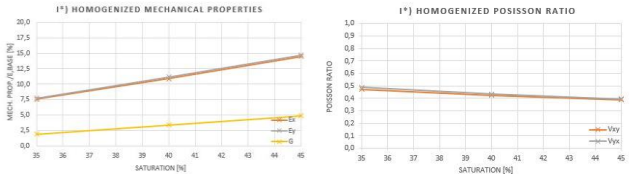
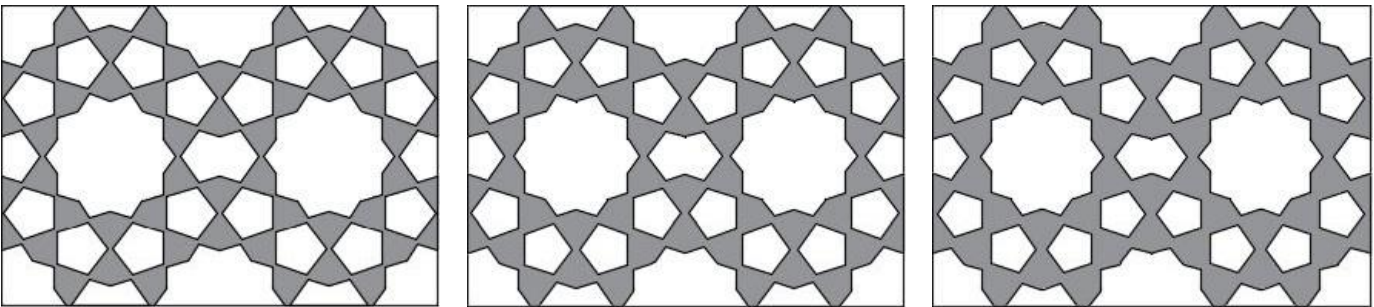


FIG AP1.6.17. Homogenized mechanical properties, pattern I*



Saturation 35%

Saturation 40%

Saturation 45%

FIG AP1.6.18. Pattern A*for different saturations

L*) BEN YUSUF MADRASA

L75*		HOMOG. MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
45	0.85	6.57%	6.57%	0.536	0.536	1.38%
50	1.62	10.76%	10.76%	0.458	0.458	2.77%
55	2.43	15.03%	15.03%	0.410	0.410	4.36%

TABLE AP1.6.10. Homogenized mechanical properties, pattern L*

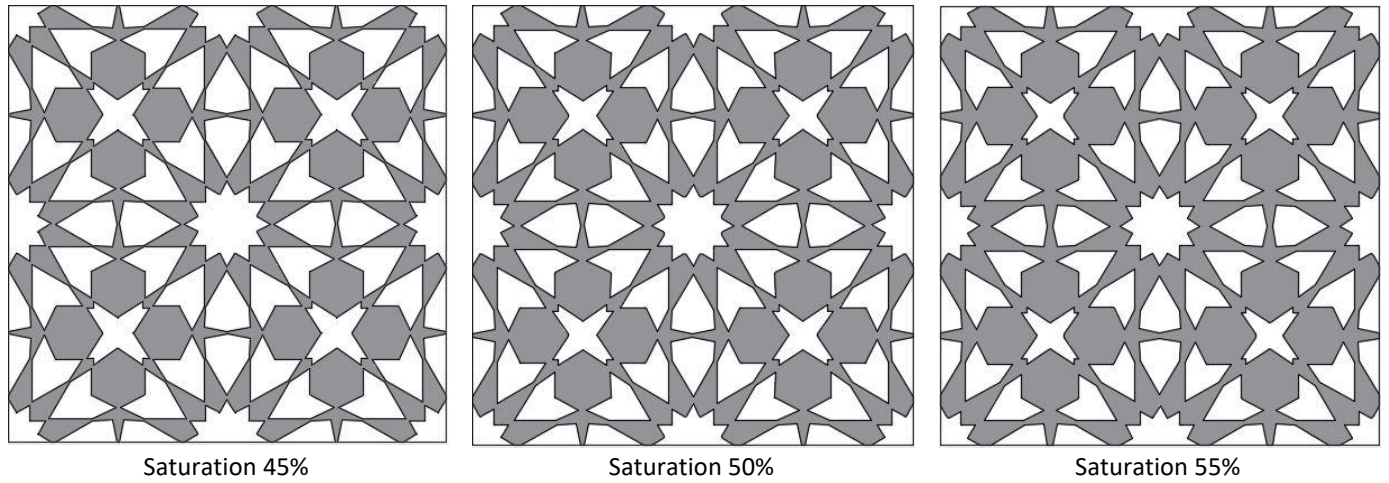
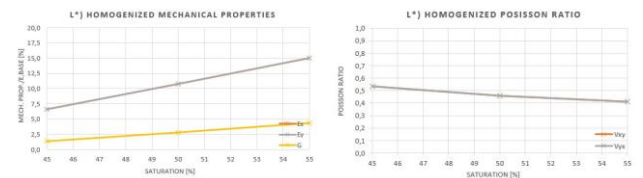


FIG AP1.6.20. Pattern A* for different saturations

M*) AL-NASIR MUHAMMAD'S MINBAR

M20*		HOMOG. MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
40	0.57	4.25%	4.25%	0.719	0.719	2.58%
45	1.04	7.81%	7.81%	0.626	0.626	3.88%
50	1.52	12.06%	12.06%	0.545	0.545	5.46%

TABLE AP1.6.11. Homogenized mechanical properties, pattern M*

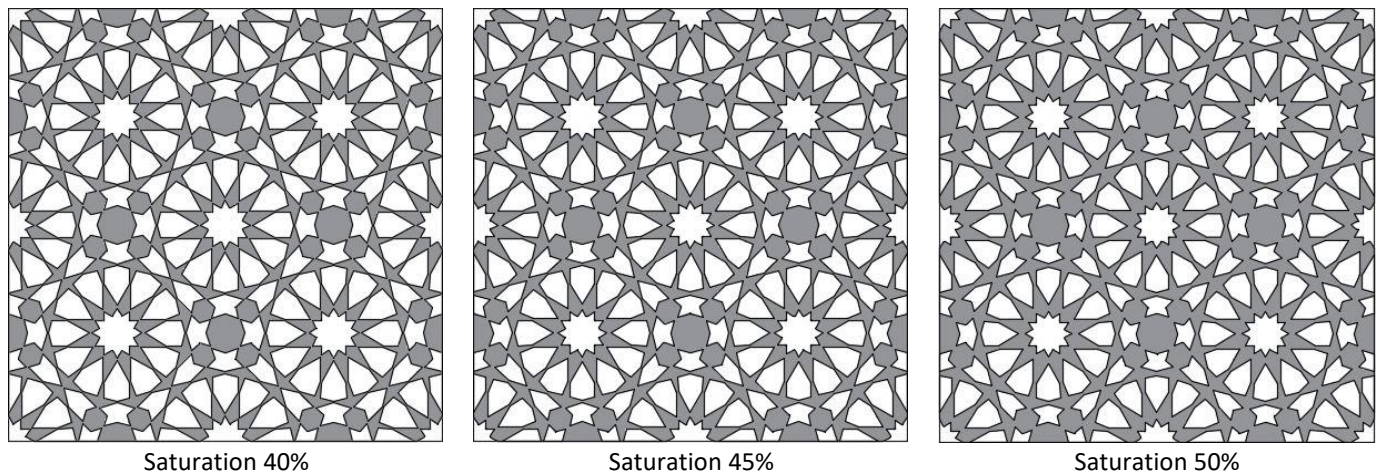
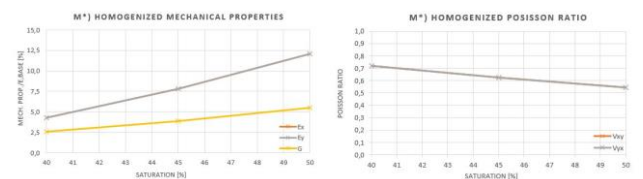
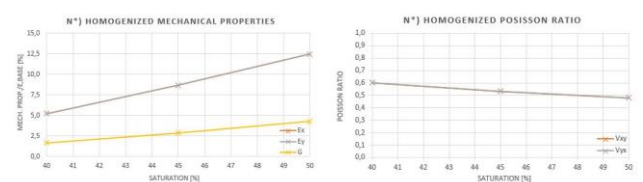


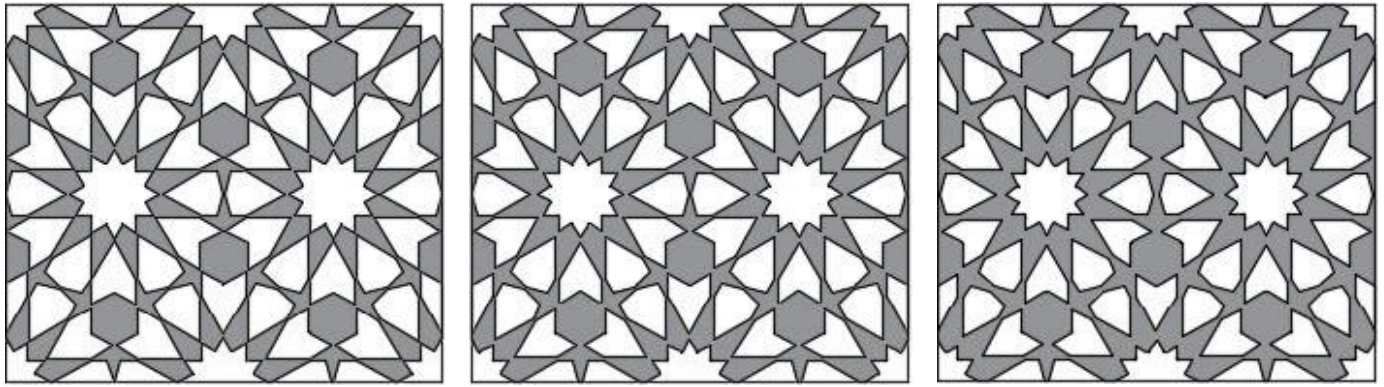
FIG AP1.6.22. Pattern A* for different saturations

N*) MOSQUE OF AL-NASIR MUHAMMAD

N75*		HOMOG. MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
40	0.72	5.23%	5.23%	0.603	0.603	1.69%
45	1.48	8.67%	8.67%	0.534	0.534	2.89%
50	2.28	12.47%	12.45%	0.479	0.479	4.28%

TABLE AP1.6.12. Homogenized mechanical properties, pattern N*





Saturation 40%

Saturation 45%

Saturation 50%

FIG AP1.6.24. Pattern A*for different saturations

O*) GREAT MOSQUE OF HERAT

O30*		HOMOG. MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
40	1.33	6.69%	6.69%	0.639	0.639	3.04%
45	2.43	10.81%	10.81%	0.560	0.560	4.97%
50	3.59	15.35%	15.35%	0.493	0.493	6.99%

TABLE AP1.6.13. Homogenized mechanical properties, pattern O*

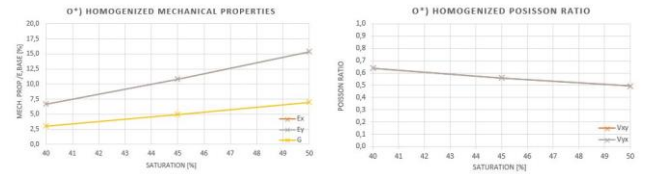
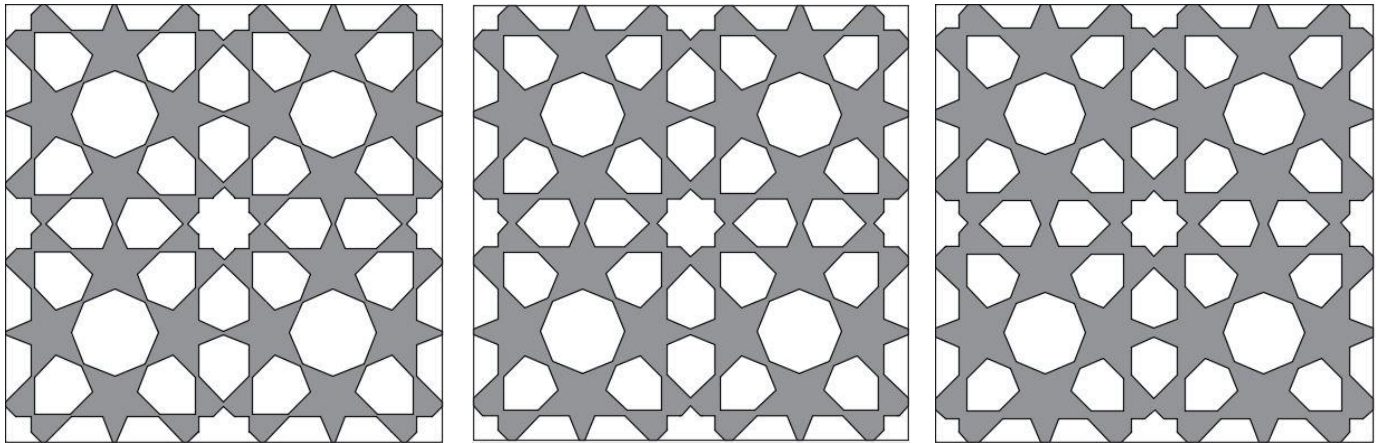


FIG AP1.6.25. Homogenized mechanical properties, pattern O*



Saturation 40%

Saturation 45%

Saturation 50%

FIG AP1.6.26. Pattern A*for different saturations

P*) MOSQUE OF AL-SALIH TALA'I

P25*		HOMOG. MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
35	1.08	9.78%	9.77%	0.410	0.409	3.71%
40	1.94	13.72%	13.72%	0.374	0.374	5.03%
45	2.85	17.71%	17.71%	0.345	0.345	6.44%

TABLE AP1.6.14. Homogenized mechanical properties, pattern P*

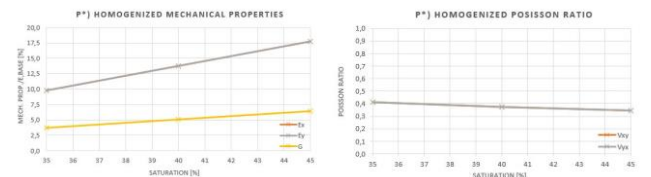
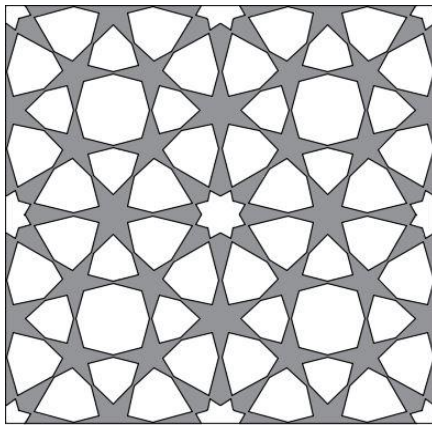
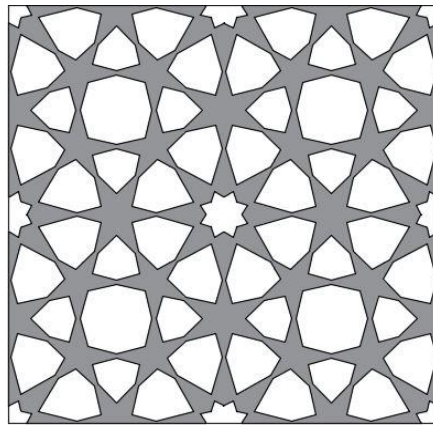


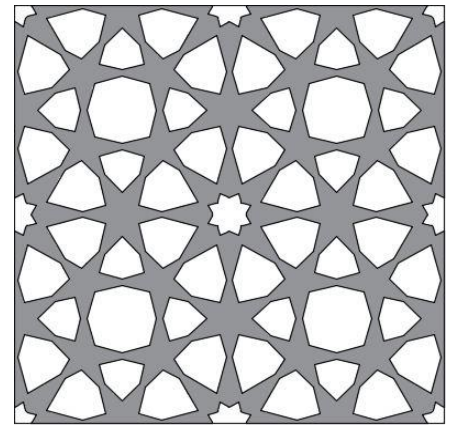
FIG AP1.6.27. Homogenized mechanical properties, pattern P*



Saturation 35%



Saturation 40%



Saturation 45%

FIG AP1.6.28. Pattern A*for different saturations

Q*) MOSQUE OF IBN TULUN

Q65*		HOMOG. MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
35	0.96	7.63%	7.63%	0.488	0.488	1.28%
40	1.74	11.00%	11.00%	0.446	0.446	2.36%
45	2.56	14.57%	14.57%	0.410	0.410	3.59%

TABLE AP1.6.15. Homogenized mechanical properties, pattern Q*

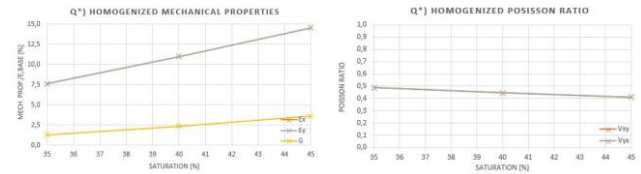
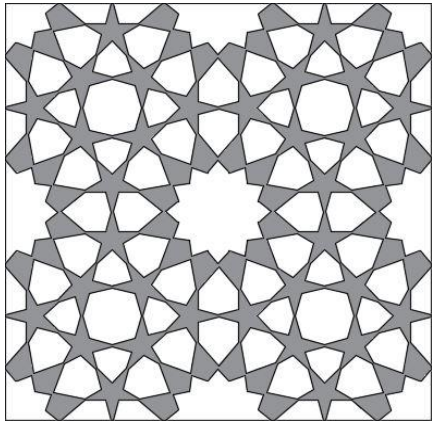
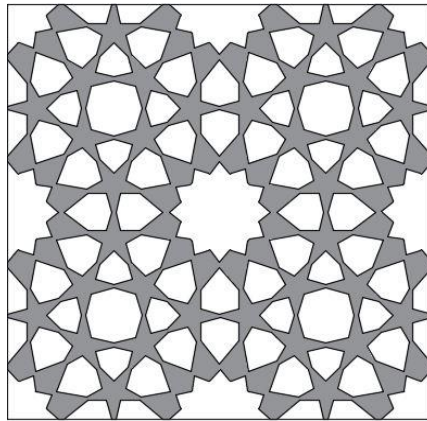


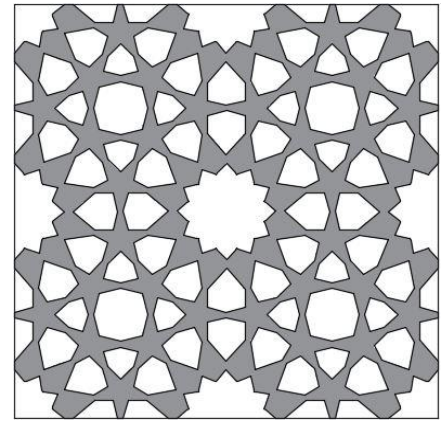
FIG AP1.6.29. Homogenized mechanical properties, pattern Q*



Saturation 35%



Saturation 40%



Saturation 45%

FIG AP1.6.30. Pattern A*for different saturations

R*) FATEHPUR SIKRI

R72*		HOMOG. MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
40	1.31	8.94%	9.01%	0.531	0.535	2.59%
45	2.06	12.98%	13.09%	0.465	0.469	3.90%
50	2.86	17.39%	17.64%	0.411	0.417	5.49%

TABLE AP1.6.16. Homogenized mechanical properties, pattern R*

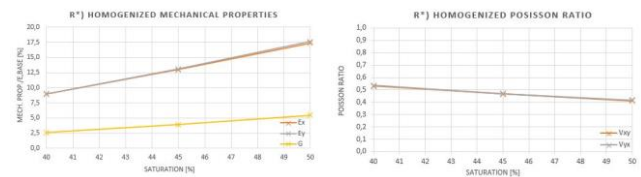
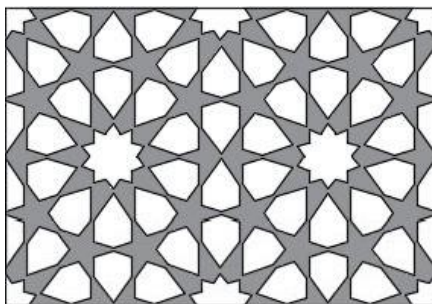
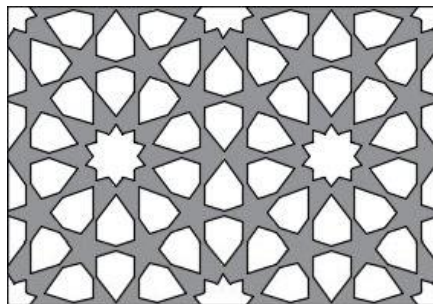


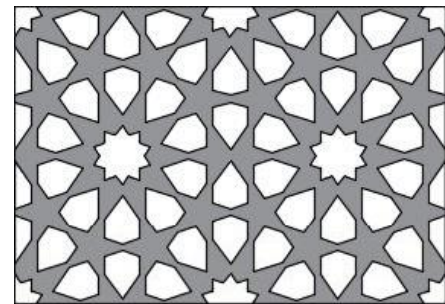
FIG AP1.6.31. Homogenized mechanical properties, pattern R*



Saturation 40%



Saturation 45%



Saturation 50%

FIG AP1.6.32. Pattern A*for different saturations

S*) JAMEH MOSQUE

S20*		HOMOG. MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
40	0.61	5.58%	5.58%	0.679	0.679	3.63%
45	1.09	9.09%	9.09%	0.606	0.606	5.11%
50	1.59	13.34%	13.34%	0.538	0.538	6.75%

TABLE AP1.6.17. Homogenized mechanical properties, pattern S*

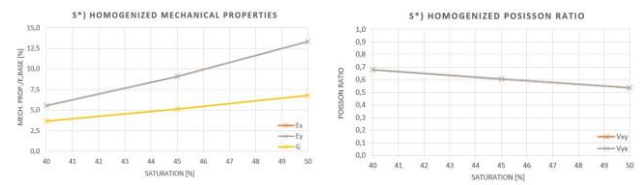
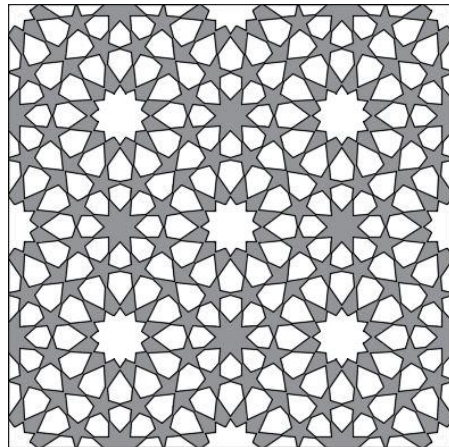
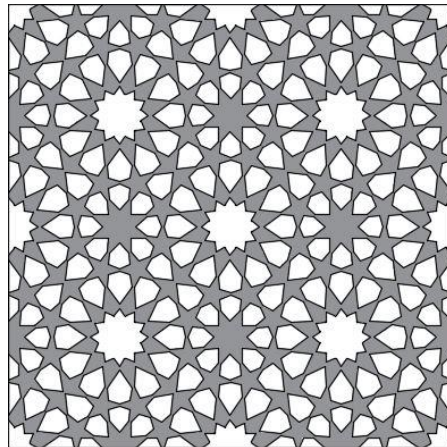


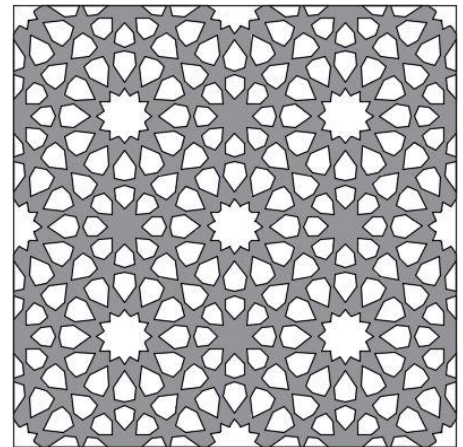
FIG AP1.6.33. Homogenized mechanical properties, pattern S*



Saturation 40%



Saturation 45%



Saturation 50%

FIG AP1.6.34. Pattern A* for different saturations

T*) ALHAMBRA

T35*		HOMOG. MECHANICAL PROPERTIES				
Sat [%]	rbd [%]	$E_{h,x}$	$E_{h,y}$	$\nu_{h,xy}$	$\nu_{h,yx}$	G_h
40	0.81	7.39%	7.37%	0.606	0.605	2.42%
45	1.31	11.26%	11.25%	0.534	0.533	3.77%
50	1.82	15.51%	15.54%	0.474	0.475	5.36%

TABLE AP1.6.18. Homogenized mechanical properties, pattern T*

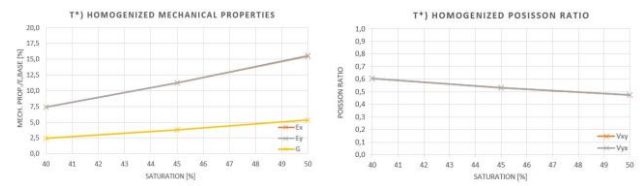
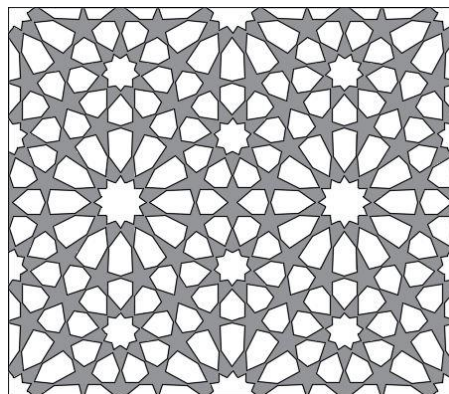
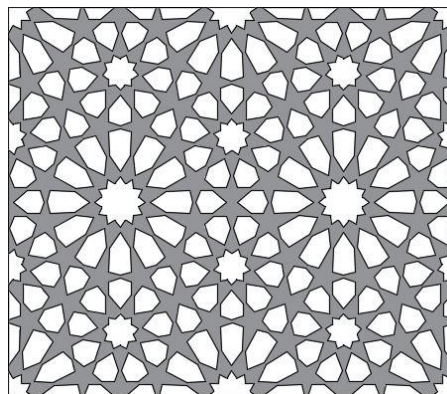


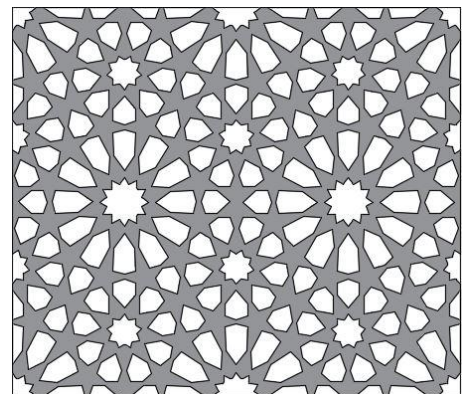
FIG AP1.6.35. Homogenized mechanical properties, pattern T*



Saturation 40%



Saturation 45%



Saturation 50%

FIG AP1.6.36. Pattern A* for different saturations