7- Course Specification of Masonry Structures (CE 589)

I. Course Identification and General Information:

1.	**Course Title:**	**Design of Masonry Structures**				
2.	**Course Code & Number:**	CE 589				
3.	**Credit hours:**	C.H				**Credit Hours**
		Lecture.	**Laboratory**	**Seminars.**		
		3	-			3
4.	**Study semester at which this course is offered:**	2nd semester				
5.	**Pre –requisite (if any):**	Strength of Material (BSc)				
6.	**Co –requisite (if any):**	Non				
7.	**Program (s) in which the course is offered:**	Master of Science in structural engineering				
8.	**Language of teaching the course:**	English/Arabic				
9.	**Course type**	Elective				
10.	**Location of teaching the course:**	Classroom				
11.	**Prepared By:**	- Prof. Dr. Abdulmalek Al-Jolahy - Dr. Sulaiman Al-Safi.				
12.	**Date of Approval**					

II. Course Description:

The course presents wide knowledge on masonry material and construction. It covers analysis and design of masonry walls and columns according to masonry codes of practice. It assists the interaction between walls and floor/roof slabs to define the load eccentricity and consequently the wall capacity reduction towards the selection of suitable masonry units and mortars. The course provides also necessary knowledge on reinforced and prestressed masonry to enable walls resist vertical and lateral actions.

III. Course Intended learning outcomes (CILOs) of the course		Reference PILOs
a.1	Demonstrate in depth understanding of knowledge of masonry materials and structures to the field of structural engineering.	A1
a.2	Recognize and Explain the contemporary engineering technologies and issues in the specialization field of masonry structural engineering.	A2
a.3	Explain in-depth the principles of sustainable design and development of masonry structures.	A3
b.1	Assess, select and apply appropriate principles, methodologies, techniques, tools and packages in the analysis, specification, development and evaluation of structural engineering systems in masonry field.	B1
b.2	Identify, formulate, analyze research and solve complex structural engineering problems in masonry field.	B2
c.1	Develop research to solve structural engineering problems in the masonry construction field.	C1
c.2	Use advanced methodology and skills to solve structural engineering problems either in the design or construction of masonry structures.	C2
c.3	Apply acquired knowledge of analysis and design for structural masonry systems and implementation process.	C3
d.1	Prepare a complete thesis and term-courses works/ tasks, write their documents and defend on them.	D1
d.3	Conduct independently and communicate research that advances and extends knowledge and benefits in structural masonry field.	D3

(A) Alignment Course Intended Learning Outcomes of Knowledge and Understanding to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	**Teaching strategies**	**Assessment Strategies**
a.1 Demonstrate in depth understanding of knowledge of masonry materials and structures to the field of structural engineering.	Lecture Directed self-study Student presentation Field visits	Written exam Field visit reports
a.2 Recognize and Explain the contemporary engineering technologies and issues in the specialization field of masonry structural engineering.		
a.3 Explain in-depth the principles of sustainable design and development of masonry structures.	Lecture Directed self-study Student presentation	Written exam Written assignment Course project

(B) Alignment Course Intended Learning Outcomes of Intellectual Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	**Teaching strategies**	**Assessment Strategies**
b.1 Assess, select and apply appropriate principles, methodologies, techniques, tools and packages in the analysis, specification, development and evaluation of structural engineering systems in masonry field.	Lecture Directed self-study Student presentation Practical classes	Written exam Written assignment Course project report Lab reports
b.2 Identify, formulate, analyze research and solve complex structural engineering problems in masonry field.		Written exam Written assignment field visit reports

(C) Alignment Course Intended Learning Outcomes of Professional and Practical Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	**Teaching strategies**	**Assessment Strategies**
c1. Develop research to solve structural engineering problems in the masonry construction field.	Lecture Directed self-study Student presentation Lab and field work	Lab and field reports Research report
c2. Use advanced methodology and skills to solve structural engineering problems either in the design or construction of masonry structures.	Lecture Directed self-study Student presentation Practical classes including computer modeling Course project	Written exam Written assignment Research reports
c3. Apply acquired knowledge of analysis and design for structural masonry systems and implementation process.		

(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	**Teaching strategies**	**Assessment Strategies**
d.1 Prepare a complete thesis and term-courses works/ tasks, write their documents and defend on them.	Lecture Directed self-study Lab and field work	Written assignment Lab and field reports Research reports
d.3 Conduct independently and communicate research that advances and extends knowledge and benefits in related fields.		

IV. Course Content:

A – Lecture Aspect:

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	contact hours
1	Introduction	a1, a2, b1, c1, c2, c3	- Masonry structures (Historical Background), - Wall materials and types, - Basic design Considerations (limit state design), - Reinforced and pre-stressed masonry, - Codes of Practice (BS 5628, EC6, TMS 402-11/ACI 530-11/ASCE 5-11, Unified Arab Code).	1	3
2	Masonry Materials	a1, a2, b1, c1, d1	- Bricks and blocks, - Manufactured and natural stones, - Mortars and grouts, - Wall ties and reinforcement.	1	3
3	Masonry properties	a1, a2, a3, b1, b2, c1, c2, c3, d1, d3	- Compressive strength (unit strength method & wallette/prism strength method), - Flexural strength - Tensile strength - Shear strength - Modulus of elasticity - Creep, Moisture Movement and Thermal Expansion	2	6
4	Design for Vertical loading /compressive loading	a1, a3, b1, b2, c2, d1, d3	- Philosophy of design to EC6 & BS 5628 - Characteristic loads - Partial safety factors for loads - Partial safety factor for material, strength - Characteristic compressive strength of masonry, f_k (EC6 & BS 5628), - Design of vertically loaded walls and columns (EC6 & BS 5628), - Slenderness, - Eccentricity of applied loading, - Load bearing capacity/ Design, compressive strength, - Selection of masonry units and mortars, (Example: Single leaf masonry wall, Example: Cavity wall), - Empirical Design Concept	3	9

			(TMS 402-11/ACI 530-11/ASCE 5-11		
5	Design for lateral loading	a1, a3, b1, b2, c2, c3, d1, d3	- Design strength of panel, - Edge support condition & continuity, - Limiting dimensions, - Design of wall for lateral loading.	2	6
6	Reinforced Masonry	a1, a3, b1, b2, c2, d1, d3	- Flexural & shear strength, - Deflection of masonry beams, - Reinforced masonry columns using BS 5628 & EC6.	2	6
7	Prestressed Masonry	a1, a3, b1, b2, c2, d1, d3	- Basic theory, - Methods of prestressing, - Loss of prestress. - Flexural stress,	1	3
Number of Weeks /and Units Per Semester				**12**	**36**

B - Laboratory Aspect:

Order	Tasks/ Experiments	Number of Weeks	contact hours	Learning Outcomes
1	Tests on masonry units, mortars and wallettes	2 (5,9)	6	c2, c3, d1, d3
Number of Weeks /and Units Per Semester		2	6	

V. Schedule of Assessment Tasks for Students During the Semester:

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course Learning Outcomes
1	Assignment & course project	5,9,13	20	20%	a1, a2, a3, b1, b2, c1, c2, c3, d1, d3
2	Lab reports	6, 10	10	10%	b1, c2, c3, d1, d3
3	Quizzes	Two times randomly	5	5%	a1, a2, a3, b1, b2, c2, c3
4	Midterm Exam	8	15	15%	a1, a2, a3, b1, b2, c2, c3
5	Final-exam	16	50	50%	a1, a2, a3, b1, b2, c2, c3
Total			100	100%	

VI. Assignments:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1	Masonry Compressive strength (BS 5628, EC6, TMS 402-11/ACI 530-11/ASCE 5-11)	a1, a2, a3, b1, b2, c1, c2, c3, d1, d3	5	5
2	Loading Capacity of Reinforced and presstress masonry walls	a1, a2, a3, b1, b2, c1, c2, c3, d1, d3	13	5
3	Design of Multi-Story masonry building for vertical loading (course Project)	a1, a2, a3, b1, b2, c1, c2, c3, d1, d3	9	10

VII. Report:

No	Assignments	Aligned CILOs (symbols)	Week Due	Mark
1	Lab report on unit and mortar strengths	a1,a2, b1,b2, c1,c2, c3, d1, d3	6	5
2	Lab report on masonry strength	a1,a2, b1,b2, c1,c2, c3, d1, d3	10	5

VIII. Learning Resources and Facilities:

1- Required Textbook(s) (maximum two).

6. Hendry A. W, Sinha, B. P. & Davies S.R, 1996, Design of Masonry Structures, Third Edition, Macmillan Education Ltd.
7. McKenzie W.M.C., 2001, Design of Structural Masonry, First Edition, Antony Rowe Ltd.

2- Code of Pracice

1. European Committee for Standardisation (ECS), 2005, "Eurocode 6, EN 1996-1-1:2005: Design of Masonry Structures, Part 1-1, Part 2 & Part 3:, Brussels, Belgium.
2. British Standards Institution, BS 5628; "Code of Practice for Use of Masonry, Part 1: Structural Use of Unreinforced Masonry", 2005 & Part 2: Structural Use of Reinforced and Prestressed Maonry 5628-2'': 2000.
3. Masonry Standard Joint Committee (MSJC), 2013, Building Code Requirements for Masonry Structures (TMS 402-13/ACI 530-13/ASCE 5-13).

3- Essential References.

1. Robert G. Drysdale, Ahmed A. Hamid, and Lawrie R. Baker, 1994, Masonry Structures Behaviour and Design, Englegood Cliffs, New Jersy, Prentice Hall International.
2. Curtin W.G, Shaw G., Beck J.K, 1999, Structural Masonry Designers' Manual, Blackwell Scientific Pupliations.
3. Masonry Insititute of America (www.masonryinsinsititute.org) & International Code Council (www.iccsafe.org), 2007, Masonry Design Manual, 4th Edition.

3- Electronic Materials and Web Sites *etc.*

-

Educational and research Facilities and Equipment Required

Technology Resources
(AV, data show, Smart Board, software, etc.)

-

Other Resources
(Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)

-

IX. Course Policies:

36.	**Class Attendance:** The students should have more than 75 % of attendance according to rules and regulations of the faculty.
37.	**Tardy:** The students should respect the timing of attending the lectures. They should attend within 10 minutes from starting of the lecture.
38.	**Exam Attendance/Punctuality:** The student should attend the exam on time. The punctuality should be implemented according to rules and regulations of the faculty for midterm exam and final exam.
39.	**Assignments & Projects**: The assignment is given to the students after each chapter, the student has to submit all the

	assignments for checking on time.
40.	**Cheating:** If any cheating occurred during the examination, the student is not allowed to continue and he/she has to face the examination committee for enquires.
41.	**Plagiarism:** The student will be terminated from the Faculty, if one student attends the exam on another behalf according to the policy, rules and regulations of the university.
42.	**Other policies:** • All the teaching materials should be kept out the examination hall. • the mobile phone is not allowed. • There should be a respect between the student and his teacher.

Reviewed By	**Vice Dean for Academic Affairs and Post Graduate Studies** **Dr. Tarek A. Barakat** **Dr. Ahmed Alwadhaf** **Dr. Mohammad Algorafi**
	Deputy Rector for Academic Affairs Dr. Ibrahim AlMutaa **Dr. Ahmed mujahed** **Dr. Munaser Alsubri**

Course Plan of Masonry Structures

I. Information about Faculty Member Responsible for the Course:

Name		**Office Hours**						
Location &Telephone No.		**SAT**	**SUN**	**MON**	**TUE**	**WED**	**THU**
E-mail							

II. Course Identification and General Information:

	Course Title:	**Design of Masonry Structures**			
2.	**Course Code & Number:**	CE 589			
3.	**Credit hours:**	C.H			**Credit Hours**
		Lecture.	**Laboratory**	**Seminars.**	
		3			3
4.	**Study semester at which this course is offered:**	2nd semester			
5.	**Pre –requisite (if any):**	Strength of Material (BSc)			
6.	**Co –requisite (if any):**	Non			
7.	**Program (s) in which the course is offered:**	Master of Science in structural engineering			
8.	**Language of teaching the course:**	English/Arabic			
9.	**Course type**	Elective			
10.	**Location of teaching the course:**	Classroom			
11.	**Prepared By:**	- Prof. Dr. Abdulmalek Al-Jolahy - Dr. Sulaiman Al-Safi.			
12.	**Date of Approval**				

III. Course Description:

The course presents wide knowledge on masonry material and construction. It covers analysis and design of masonry walls and columns according to masonry codes of practice. It assists the interaction between walls and floor/roof slabs to define the load eccentricity and consequently the wall capacity reduction towards the selection of suitable masonry units and mortars. The course provides also necessary knowledge on reinforced and prestressed masonry to enable walls resist vertical and lateral actions.

IV. Course Intended learning outcomes (CILOs) of the course

		Reference PILOs
a.1	Demonstrate in depth understanding of knowledge of masonry materials and structures to the field of structural engineering.	A1
a.2	Recognize and Explain the contemporary engineering technologies and issues in the specialization field of masonry structural engineering.	A2
a.3	Explain in-depth the principles of sustainable design and development of	A3

	masonry structures.	
b.1	Assess, select and apply appropriate principles, methodologies, techniques, tools and packages in the analysis, specification, development and evaluation of structural engineering systems in masonry field.	B1
b.2	Identify, formulate, analyze research and solve complex structural engineering problems in masonry field.	B2
c.1	Develop research to solve structural engineering problems in the masonry construction field.	C1
c.2	Use advanced methodology and skills to solve structural engineering problems either in the design or construction of masonry structures.	C2
c.3	Apply acquired knowledge of analysis and design for structural masonry systems and implementation process.	C3
d.1	Prepare a complete thesis and term-courses works/ tasks, write their documents and defend on them.	D1
d.3	Conduct independently and communicate research that advances and extends knowledge and benefits in structural masonry field.	D3

(A) Alignment Course Intended Learning Outcomes of Knowledge and Understanding to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	**Teaching strategies**	**Assessment Strategies**
a.1 Demonstrate in depth understanding of knowledge of masonry materials and structures to the field of structural engineering.	Lecture Directed self-study Student presentation Field visits	Written exam Field visit reports
a.2 Recognize and Explain the contemporary engineering technologies and issues in the specialization field of masonry structural engineering.		
a.3 Explain in-depth the principles of sustainable design and development of masonry structures.	Lecture Directed self-study Student presentation	Written exam Written assignment Course project

(B) Alignment Course Intended Learning Outcomes of Intellectual Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	**Teaching strategies**	**Assessment Strategies**
b.1 Assess, select and apply appropriate principles, methodologies, techniques, tools and packages in the analysis, specification, development and evaluation of structural engineering systems in masonry field.	Lecture Directed self-study Student presentation Practical classes	Written exam Written assignment Course project report Lab reports
b.2 Identify, formulate, analyze research and solve complex structural engineering problems in masonry field.		Written exam Written assignment field visit reports

(C) Alignment Course Intended Learning Outcomes of Professional and Practical Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	**Teaching strategies**	**Assessment Strategies**
c1. Develop research to solve structural engineering problems in the masonry construction field.	Lecture Directed self-study Student presentation Lab and field work	Lab and field reports Research report
c2. Use advanced methodology and skills to solve structural engineering problems either in the design or construction of masonry structures.	Lecture Directed self-study Student presentation Practical classes including computer modeling Course project	Written exam Written assignment Research reports
c3. Apply acquired knowledge of analysis and design for structural masonry systems and implementation process.		

(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	**Teaching strategies**	**Assessment Strategies**
d.1 Prepare a complete thesis and term-courses works/ tasks, write their documents and defend on them.	Lecture Directed self-study Lab and field work	Written assignment Lab and field reports Research reports
d.3 Conduct independently and communicate research that advances and extends knowledge and benefits in related fields.		

V. Course Content:

A – Lecture Aspect:

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	contact hours
1	Introduction	a1, a2, b1, c1, c2, c3	- Masonry structures (Historical Background), - Wall materials and types, - Basic design Considerations (limit state design), - Reinforced and pre-stressed masonry, - Codes of Practice (BS 5628, EC6, TMS 402-11/ACI 530-11/ASCE 5-11, Unified Arab Code).	1	3
2	Masonry Materials	a1, a2, b1, c1, d1	- Bricks and blocks, - Manufactured and natural stones, - Mortars and grouts, - Wall ties and reinforcement.	1	3
3	Masonry properties	a1, a2, a3, b1, b2, c1, c2, c3, d1, d3	- Compressive strength (unit strength method & wallette/prism strength method), - Flexural strength - Tensile strength - Shear strength - Modulus of elasticity - Creep, Moisture Movement and Thermal Expansion	2	6
4	Design for Vertical loading /compressive loading	a1, a3, b1, b2, c2, d1, d3	- Philosophy of design to EC6 & BS 5628 - Characteristic loads - Partial safety factors for loads - Partial safety factor for material, strength - Characteristic compressive strength of masonry, f_k (EC6 & BS 5628), - Design of vertically loaded walls and columns (EC6 & BS 5628), - Slenderness, - Eccentricity of applied loading, - Load bearing capacity/ Design, compressive strength, - Selection of masonry units and mortars, (Example: Single leaf masonry wall, Example: Cavity wall), - Empirical Design Concept (TMS 402-11/ACI 530-11/ASCE 5-11	3	9

5	Design for lateral loading	a1, a3, b1, b2, c2, c3, d1, d3	- Design strength of panel, - Edge support condition & continuity, - Limiting dimensions, - Design of wall for lateral loading.	2	6
6	Reinforced Masonry	a1, a3, b1, b2, c2, d1, d3	- Flexural & shear strength, - Deflection of masonry beams, - Reinforced masonry columns using BS 5628 & EC6.	2	6
7	Prestressed Masonry	a1, a3, b1, b2, c2, d1, d3	- Basic theory, - Methods of prestressing, - Loss of prestress. - Flexural stress,	1	3
Number of Weeks /and Units Per Semester				**12**	**36**

B - Laboratory Aspect:

Order	Tasks/ Experiments	Number of Weeks	contact hours	Learning Outcomes
1	Tests on masonry units, mortars and wallettes	2 (5,9)	6	c2, c3, d1, d3
Number of Weeks /and Units Per Semester		**2**	**6**	

VI. Schedule of Assessment Tasks for Students During the Semester:

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course Learning Outcomes
1	Assignment & course project	5,9,13	20	20%	a1, a2, a3, b1, b2, c1, c2, c3, d1, d3
2	Lab reports	6, 10	10	10%	b1, c2, c3, d1, d3
3	Quizzes	Two times randomly	5	5%	a1, a2, a3, b1, b2, c2, c3
4	Midterm Exam	8	15	15%	a1, a2, a3, b1, b2, c2, c3
5	Final-exam	16	50	50%	a1, a2, a3, b1, b2, c2, c3
Total			**100**	**100%**	

VII. Assignments:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1	Masonry Compressive strength (BS 5628, EC6, TMS 402-11/ACI 530-11/ASCE 5-11)	a1, a2, a3, b1, b2, c1, c2, c3, d1, d3	5	5
2	Loading Capacity of Reinforced and presstress masonry walls	a1, a2, a3, b1, b2, c1, c2, c3, d1, d3	13	5

3	Design of Multi-Story masonry building for vertical loading (course Project)	a1, a2, a3, b1, b2, c1, c2, c3, d1, d3	9	10

VIII. Report:

No	Assignments	Aligned CILOs (symbols)	Week Due	Mark
1	Lab report on unit and mortar strengths	a1,a2, b1,b2, c1,c2, c3, d1, d3	6	5
2	Lab report on masonry strength	a1,a2, b1,b2, c1,c2, c3, d1, d3	10	5

X. Learning Resources and Facilities:

1- Required Textbook(s) (maximum two).

1. Hendry A. W, Sinha, B. P. & Davies S.R, 1996, Design of Masonry Structures, Third Edition, Macmillan Education Ltd.
2. McKenzie W.M.C., 2001, Design of Structural Masonry, First Edition, Antony Rowe Ltd.

2- Code of Pracice

1. European Committee for Standardisation (ECS), 2005, "Eurocode 6, EN 1996-1-1:2005: Design of Masonry Structures, Part 1-1, Part 2 & Part 3:, Brussels, Belgium.
2. British Standards Institution, BS 5628; "Code of Practice for Use of Masonry, Part 1: Structural Use of Unreinforced Masonry", 2005 & Part 2: Structural Use of Reinforced and Prestressed Maonry 5628-2'': 2000.
1. Masonry Standard Joint Committee (MSJC), 2013, Building Code Requirements for Masonry Structures (TMS 402-13/ACI 530-13/ASCE 5-13).

3- Essential References.

1. Robert G. Drysdale, Ahmed A. Hamid, and Lawrie R. Baker, 1994, Masonry Structures Behaviour and Design, Englegood Cliffs, New Jersy, Prentice Hall International.
2. Curtin W.G, Shaw G., Beck J.K, 1999, Structural Masonry Designers' Manual, Blackwell Scientific Pupliations.
3. Masonry Insititute of America (www.masonryinsinsititute.org) & International Code Council (www.iccsafe.org), 2007, Masonry Design Manual, 4th Edition.

3- Electronic Materials and Web Sites *etc.*

-

Educational and research Facilities and Equipment Required

Technology Resources
(AV, data show, Smart Board, software, etc.)

-

Other Resources
(Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)

-

XI. Course Policies:

43.	**Class Attendance:** The students should have more than 75 % of attendance according to rules and regulations of the faculty.
44.	**Tardy:** The students should respect the timing of attending the lectures. They should attend within

	10 minutes from starting of the lecture.
45.	**Exam Attendance/Punctuality:** The student should attend the exam on time. The punctuality should be implemented according to rules and regulations of the faculty for midterm exam and final exam.
46.	**Assignments & Projects**: The assignment is given to the students after each chapter, the student has to submit all the assignments for checking on time.
47.	**Cheating:** If any cheating occurred during the examination, the student is not allowed to continue and he/she has to face the examination committee for enquires.
48.	**Plagiarism:** The student will be terminated from the Faculty, if one student attends the exam on another behalf according to the policy, rules and regulations of the university.
49.	**Other policies**: • All the teaching materials should be kept out the examination hall. • the mobile phone is not allowed. • There should be a respect between the student and his teacher.

Reviewed By	**Vice Dean for Academic Affairs and Post Graduate Studies** **Dr. Tarek A. Barakat** **Dr. Ahmed Alwadhaf** **Dr. Mohammad Algorafi**
	Deputy Rector for Academic Affairs Dr. Ibrahim AlMutaa **Dr. Ahmed mujahed** **Dr. Munaser Alsubri**