

**GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)****Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)**

Semester-VI

**Course Title: Construction Quality Control & Monitoring**

(Course Code: 4360608 )

<b>Diploma program in which this course is offered</b>	<b>Semester in which offered</b>
Civil Engineering	6 <sup>th</sup> Semester

**1.RATIONALE**

In rapidly developing countries like India, where infrastructure projects are booming, ensuring quality control and monitoring in construction is crucial for achieving durable and sustainable structures within planned timeframes. For any civil engineering project, regular day-to-day inspections and monitoring play a vital role in maximizing lifespan and minimizing environmental impact. Implementing robust quality control measures can extend the life of civil structures by its design life without significant cost increases. This becomes especially vital considering the depletion of construction resources and the growing emphasis on sustainability. Therefore, for diploma students aspiring to a career in civil engineering, understanding green building concepts and thorough quality control practices is indispensable. Their future roles will likely involve supervisory positions, making them directly responsible for upholding construction quality. Thus, mastering these skills equips them to perform their duties efficiently, effectively, and with environmental responsibility in mind.

**2.COMPETENCY**

The course content should be taught and implemented with the aim to develop required skills in the students so that they are able to acquire following competency:

- Effectively& efficiently control and supervise Civil construction materials & activities.

**3.COURSE OUTCOMES (COs)**

The theory should be taught and exercises should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

- Apply total quality management in civil construction.
- Check the quality in civil construction works.
- Identify the variations in quality of civil works.
- Use various standard codes in civil construction works.
- Study various policies and do green audit of the building.
- Design energy efficient buildings.

#### 4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T/2+P/2)	Examination Scheme				
L	T	P		Theory Marks		Practical Marks		Total Marks
			C	CA	ESE	CA	ESE	
3	0	2	4	30*	70	25	25	150

(\*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate the integration of COs, and the remaining 20 marks is the average of 2 tests to be taken during the semester for assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

**Legends:** L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P -Practical; C – Credit, CA - Continuous Assessment; ESE -End Semester Examination.

#### 5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the sub-components of the COs. Some of the **PrOs** marked **\*\*** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Prepare & Perform Power Point Presentation highlighting key features of TQM like principles, Aims, Short notes on TQM models, Mantras, building block of TQM, Driving forces & other relevant definitions	I	6*
2	Prepare Various Quality Check lists of the following Construction materials and activities, a) Masonry b) Plastering c) Flooring d) Concreting of various building elements e) Formwork & Scaffolding f) Steel Fabrication g) Door & Windows h) Plumbing & Drainage i) Water Proofing – Terrace and Bathroom sunk j) External and Internal Painting k) Building materials – Brick, Cement, Sand, Aggregate, Concrete, Steel	II	6*
3	Conduct field visit to perform quality checks of various construction activities and building materials.	II	4*
4	Solve minimum 8(eight) examples related to the Statistical Quality Control and Statistical Process Control.	III	8*

5	Prepare Power Point Presentation on the important clauses of IS, ISO and NBC	IV	Home* assignment
6	Prepare Power Point Presentation explaining systematic process of green building audit through GRIHA.	V	Home* assignment
7	Prepare Power Point Presentation explaining systematic process of green building audit through IGBC.	V	Home* assignment
8	Conduct physical field visit of nearby green building or virtual/video tour of green building and make comparative report with non-green building.	V	4*

### Note

- i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.
- ii. The following are some sample 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed Practical Exercises of this course required which are embedded in the COs and ultimately the competency.

### 6.MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment's with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practical in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No
1	File papers, Charts & Drawing instruments	2,3 & 4
2	Computing Devices, Computer	1, 5,6,7,8
3	Projector	1

### 7.AFFECTIVE DOMAIN OUTCOMES

The following **sample** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned Cos and PrOs. More could be added to fulfil the development of this competency.

- a) Demonstrate working as a leader/a team member.
- b) Follow safety practices on site.
- c) Follow ethical practices.
- d) Practice environmentally friendly methods and processes. (Environment related)

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- i. 'Valuing Level' in 1<sup>st</sup> year ii.
- 'Organization Level' in 2<sup>nd</sup> year.
- iii. 'Characterization Level' in 3<sup>rd</sup> year.

**8. UNDERPINNING THEORY** Only the major Underpinning Theory is formulated as higher level UOs of *Revised Bloom's taxonomy* in order for the development of the COs and competency is not missed out by the students and teachers. If required, more such higherlevel UOs could be included by the course teacher to focus on attainment of COs and competency.

<b>Unit</b>	<b>Major Learning Outcomes (in Cognitive Domain)</b>	<b>Topics and Sub-topics</b>
-------------	--	------------------------------

<p><b>Unit-I</b></p> <p><b>Total Quality Management (TQM) in Construction</b></p>	<p>1.a Explain features of TQM</p> <p>1.b Apply various quality checks.</p> <p>1.c Distinguish between quality control and quality assurance.</p> <p>1.d Explain Quality assurance techniques</p> <p>1.e List precision in observation in data and information</p> <p>1.f Explain continuous improvement and innovation</p> <p>1.g Describe employee Involvement and Training.</p>	<p>1.1 Concept of</p> <p>1.1.1 Quality control,</p> <p>1.1.2 Quality Assurance, 1.1.3 Quality management.</p> <p>1.2 Aims of TQM</p> <p>1.3 Importance of quality</p> <p>1.4 Elements of quality – Quality assurance techniques (inspection, testing, sampling)</p> <p>1.5 Use of manuals and checklists for quality control</p> <p>1.6 Development and design Concept of TQM</p> <p>1.7 Accuracy and precision in observation, reading, calibration, testing, measurements, recording of data and information etc.</p> <p>1.8 Quality Improvement Techniques CONQUAS- Construction Quality Assessment System</p> <p>1.9 Continuous Improvement and Innovation</p> <p>1.9.1 Continuous improvement models (e.g., PDCA cycle) in construction</p> <p>1.9.2 Encouraging innovation and improvement within construction projects</p> <p>1.10 Employee Involvement and Training</p> <ul style="list-style-type: none"> <li>• Importance of employee involvement in TQM</li> <li>• Training programs for construction personnel to ensure quality</li> </ul> <p>1.11 Case Studies and Best Practices Analyzing</p> <ul style="list-style-type: none"> <li>• Successful TQM implementations in construction</li> <li>• Learning from real-world examples and best practices.</li> </ul>
---	--	---

<p><b>Unit-II</b></p> <p><b>Construction Quality Control Inspection Program</b></p>	<p>2.a Explain Fundamental Concepts &amp; principles of quality control (QC) and quality assurance (QA) in construction, including the roles and responsibilities of various stakeholders.</p> <p>2.b Apply various inspection methods and procedures suited for different construction materials, systems, and stages of the project.</p> <p>2.c Make use of skills in collecting accurate and consistent quality inspection data, employing statistical analysis tools for quality control, and reporting findings effectively.</p> <p>2.d Utilize construction QC software for data management, reporting, and communication.</p> <p>2.e Develop high ethical standards in inspections and reporting, ensuring objectivity and accuracy.</p>	<p>2.1 Concept of QA &amp; QC</p> <p>2.2 Benefits of effective QA &amp; QC</p> <p>2.3 Roles &amp; responsibilities of stakeholders.</p> <p>2.4 Check lists for</p> <p>2.4.1 Masonry</p> <p>2.4.1 Plastering</p> <p>2.4.1 Flooring</p> <p>2.4.1 Concreting of various building elements</p> <p>2.4.1 Formwork &amp; Scaffolding</p> <p>2.4.1 Steel Fabrication</p> <p>2.4.1 Door &amp; Windows</p> <p>2.4.1 Plumbing &amp; Drainage</p> <p>2.4.1 Water Proofing – Terrace and Bathroom sunk</p> <p>2.4.1 External and Internal Painting</p> <p>2.4.1 Building materials – Brick, Cement, Sand, Aggregate, Concrete, Steel</p> <p>2.5 Orientation of the basic construction QC software.</p> <p>2.6 Ethical Standards in Inspections and Reporting</p> <p>2.6.1 Understanding Ethical Principles</p> <p>2.6.2 Objectivity in Inspections</p> <p>2.6.3 Accuracy and Completeness in Reporting</p>
---	---	--

<b>Unit-III</b>  <b>Statistical Quality Control &amp; Monitoring</b>	3.a Describe statistical quality principles and Importance. 3.b Explain variables and attributes related to control charts. 3.c Explain SPC methods 3.d Describe different types of Attributes-sampling plans. 3.e Explain acceptance sampling. 3.f Interpret different type of charts.	3.1 Introduction to Statistical Quality Control in Construction 3.1.1 Overview of Statistical Quality Control (SQC) principles 3.1.2 Importance of SQC in building construction 3.2 Quality Measurement: Attributes and Variables 3.3 Statistical Process Control (SPC) Methods 3.4 Control Charts for Attributes: 3.4.1 p-Charts - Proportion Defective 3.4.1 c-Charts - Number of Defects Per Unit 3.5 Control Charts for Variables 3.6 Other Types of Attribute-Sampling Plans 3.7 Acceptance Sampling
<b>Unit-IV</b>  <b>Quality Standards</b>	4.a Explain Importance of Construction Quality Standards 4.b Describe Benefits of Construction Industry Quality Standards 4.c Explain key features of National Building Code of India 2016 (NBC 2016) 4.d Explain key features of ISO Standards for the Construction Industry	4.1 Quality standards of various building materials and construction activities. 4.2 Study of Indian Standard Code for Civil Engineering (a) Orientation of the mostly used IS codes as far as the building quality is concerned 4.3 Study of National Building code (NBC 2016) Part 0 to 12 (a) Objectives (b) Basic Content of each part (c) Application 4.4 Study of ISO 9001 - the international standard for quality management 4.5 Study of ISO 14001 - the international standard for environmental management systems 4.6 Study of ISO 50001 - the international standard for energy management systems 4.7 Study of ISO 45001 - the international standard for health and safety management. 4.8 Study of ISO 44001 - the international standard for collaborative working

<b>Unit-V Green Building &amp; Sustainable Construction Development</b>	<p>5.a Describe existing Building construction scenario in India</p> <p>5.b Explain - ‘Sustainable Buildings’ in India.</p> <p>5.c Explain - Net Zero emission buildings List Government incentives for green building, Emerging policy, regulatory tools and</p>	<p>5.1 Sustainable buildings &amp; construction</p> <p>5.2 Zero net emissions in existing and new buildings:</p> <p>5.3 Definition – Green Building, Green Construction, Objectives of Green building</p> <p>5.4 Green building case studies</p> <p>5.5 Energy conservation act 2001</p> <p>5.6 National Water Policy, 2002</p> <p>5.7 Integrated Energy Policy 2006</p>
	<p>opportunities</p> <p>5.d Explain in detail – “Building Rating systems”</p>	<p>5.8 Missions under the national climate action plan</p> <p>5.9 Energy conservation building code (ECBC-2007)</p> <p>5.10 Appliance standards and labeling</p> <p>5.11 Building certification: Green Rating for Integrated Housing Assessment (GRIHA)</p> <p>5.12 Leadership in Energy and Environmental Design (LEED)</p> <p>5.13 EDGE: green building certification system</p> <p>5.14 IGBC rating system</p> <p>5.15 GEM rating system</p> <p>5.16 Eco Niwas Samhita 2018</p> <p>5.17 National Mission on Sustainable Habitat (NMSH)</p>

<b>Unit-VI Life Cycle Assessment for Building Products</b>	6.a Explain - Life Cycle Assessment	6.1 Introduction to Life cycle assessment (LCA) 6.2 Siting and structure design efficiency
	6.b Describe about Efficient life cycles for buildings	6.3 Energy efficiency 6.4 Water efficiency
	6.c Explain Green Building Guide to Reducing Waste	6.5 Materials efficiency 6.6 Occupant health and safety
	6.d Explain Procedure of Implementing construction waste management (CWM) in India	6.7 Indoor environmental quality enhancement 6.8 Operations and maintenance optimization 6.9 Waste reduction 6.10 Planning Deconstruction 6.11 Reusing and Repurposing Materials 6.12 End of Life Options for Common Building Materials 6.13 Quantum & composition of Construction & demolition (C&D) waste generation 6.14 Initiatives in promoting C & D waste products by GoI 6.15 Introduction to Guidelines on Environmental Management of C&D Wastes

**Note:** The UOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.

### 9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Total Quality Management (TQM) in Construction	7	4	3	4	11
II	Construction Quality Control Inspection Program	8	3	5	5	13
III	Statistical Quality Control & Monitoring	8	4	4	5	13
IV	Quality Standards	7	4	3	4	11
V	Green Building & Sustainable Construction Development	7	3	5	5	13
VI	Life Cycle Assessment for Building Products	5	2	3	4	9

<b>Total</b>	<b>42</b>	<b>20</b>	<b>23</b>	<b>27</b>	<b>70</b>
--------------	-----------	-----------	-----------	-----------	-----------

**Legends:** R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)

**Note:** This specification table provides general guidelines to assist students in their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U, and A) in the question paper may vary slightly from the above table.

## 10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, the following are the suggested student-related **co-curricular** activities that can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct the following activities in groups and prepare reports of about 5 pages for each activity, also collect/record physical evidence for their (student's) portfolio which will be useful for their placement interviews:

- a) Undertake micro project
- b) Prepare checklists of various construction activities
- c) Prepare lists of various IS codes with their application domain
- d) Prepare drawings and calculations
- e) Prepare presentations
- f) Prepare Site visit reports
- g) Study various processes for green building audit
- h) Visit the nearby green buildings
- i) Conduct expert lectures of quality experts and green building auditors

## 11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

- a) Massive open online courses (**MOOCs**) may be used to teach various topics/sub-M topics.
- b) Guide student(s) in undertaking micro-projects.
- c) '**L**' in **section No. 4** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
- d) About **20% of the topics/sub-topics** which are relatively simpler or descriptive in nature is to be given to the students for **self-learning**, but to be assessed using different assessment methods.
- e) With respect to **section No.11**, teachers need to ensure the creation of opportunities and provisions for **co-curricular activities**.
- f) Guide students on how to address issues on environmental and sustainability
- g) Expert lecture by water resource engineer about the emerging scenario of this field or industry experts

## 12. SUGGESTED MICRO-PROJECTS

**Only one micro-project** is planned to be undertaken by a student that needs to be assigned to him/her at the beginning of the semester. In the first four semesters, the micro-project is group-based. However, in the fifth and sixth semesters, it should preferably be **individually** undertaken to build up the skill and confidence in every student to become a problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should **not exceed three**.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based, or field-based. Each macro-project should encompass two or more Cos which are in fact, integrations of PrOs, UOs and ADOs. Each student will have to maintain a date work diary consisting of individual contributions to the project work and given seminar presentation of it before submission. The total Duration of the micro-project work should not be less than 16 [sixteen] student engagement hours during the course. The student ought to submit a micro-project by the end the semester to develop the industry-oriented Cos.

### 1. Site Visit:

- a. Choose a project showcasing diverse quality control methods: Opt for a site with construction elements like concrete pouring, foundation inspection, material testing, and steel structure assembly.
- b. Pre-brief students: Prepare specific questions and areas of focus for students to observe during the visit. This ensures active engagement and targeted learning.
- c. Post-visit discussion: Facilitate a panel discussion with project engineers or quality control supervisors to delve deeper into challenges, successes, and future trends in quality control.

### 2. Video Films:

- a. Go beyond basic material testing: Showcase innovative techniques like drone-based inspection, thermal imaging for detecting thermal bridges, and non-destructive testing methods.
- b. Curate diverse materials: Include videos testing not just basic materials like concrete and steel, but also specialized elements like waterproofing membranes, geosynthetics, and prefabricated components.
- c. Interactive viewing: Pause at key points to ask students questions, solicit predictions, and highlight important details they might miss.

### 3. Expert Lectures:

- a. Focus on specific areas: Invite experts specializing in crucial aspects like soil testing, concrete mix design, quality control for sustainable materials, or digital tools for quality monitoring.
- b. Interactive format: Encourage Q&A sessions, panel discussions, and student case presentations to ensure a dynamic learning experience.
- c. Case study integration: Ask the experts to discuss real-world projects they've handled, highlighting both successes and lessons learned from quality control failures.

### 4. Case Studies:

- a. Select diverse failures: Show examples of structural collapses, material degradation, fire safety issues, and environmental impacts caused by quality control problems.

- b. Emphasize root causes: Go beyond just showcasing failures. Analyze the technical and human factors that led to them, encouraging critical thinking and risk identification.
- c. Integrate with other activities: Use case studies as discussion points after site visits, expert lectures, or video screenings to solidify learning and connect theory with practical application.

### 13. SUGGESTED LEARNING RESOURCES

#### A. BOOKS:

No.	TITLE	AUTHOR	PUBLISHER
1	Total Quality Management	G.Kanji	Springer Science & Business Media
2	Fundamentals of Quality Control and Improvement	Amitva Mitra	Wiley India Private Limited
3	Construction Project management, Theory & Practice	Kumar Neeraj Jha	Pearson Education India
4	Project Planning with PERT and CPM	B. C. Punmia, K. K. Khandelwal	Laxmi Publications
5	Construction Planning and Management	P. S. Gehlot and B. M. Dhir	Wiley Eastern Ltd.
6	Construction of Structures and Management of Works	S. C. Rangwala	Charotar Publications
7	Manual on Quality Control	--	Gujarat Engineering Research Institute
8	Ambuja Technical Literature Series	--	Ambuja Cements
9	Construction Project Management	K. K. Chitkara	Tata McGraw-Hill Education
10	National Building Code, ISO 9000/14000 and other standards		

## 14. Learning Website:

List of Readings for each Chapter including and not limited to

- i. [www.nptel.ac.in](http://www.nptel.ac.in)
- ii. <http://ndrfandcd.gov.in/Cms/NATIONALBUILDINGCODE.aspx>
- iii. [http://en.wikipedia.org/wiki/Green\\_building\\_in\\_India](http://en.wikipedia.org/wiki/Green_building_in_India) iv. <https://edge.gbci.org/>
- v. <https://www.teriin.org/>
- vi. <https://www.cseindia.org/greening-our-buildings-what-is-the-government-doing-2731>
- vii. <https://igbc.in/>
- viii. <https://www.niua.org/csc/assets/pdf/key-documents/phase-2/CSCAF-2.0->
- ix. [https://www.niua.org/csc/assets/pdf/CSCAF\\_2\\_Booklet.pdf](https://www.niua.org/csc/assets/pdf/CSCAF_2_Booklet.pdf)
- x. <https://heyzine.com/flip-book/31ddf6adfe.html#page/1>
- xi. Climate Smart Cities Assessment 2.0. Process Video
- xii. <https://www.youtube.com/watch?v=WHq7ZTtPrsk>
- xiii. <https://edgebuildings.com/wp-content/uploads/2021/11/IFC0060-EDGEBrochure-India-2021-11-03-FIN.pdf> xiv. <https://gbci.org/press-kit-edge>
- xv. <https://www.grihaindia.org/about-griha>
- xvi. <https://www.youtube.com/watch?v=ugGPJOQYs1A>
- xvii. [https://www.beeindia.gov.in/sites/default/files/ECBC\\_BOOK\\_Web.pdf](https://www.beeindia.gov.in/sites/default/files/ECBC_BOOK_Web.pdf)
- xviii. <https://www.cseindia.org/india-manages-to-recover-and-recycle-only-about-1-per-cent-of-its-construction-and-demolition-10326>
- xix. <https://www.indiawaterportal.org/articles/implementing-construction-waste-management-india>
- xx. <https://cpcb.nic.in/openpdffile.php?id=TGF0ZXN0RmlsZS8xNTIfMTQ5NTQ0NjM5N19tZWRpYXBob3RvMTkyLnBkZg> xxi. <https://cpcb.nic.in/openpdffile.php?id=TGF0ZXN0RmlsZS8xNTIfMTQ5NTQ0NjM5N19tZWRpYXBob3RvMTkyLnBkZg> xxii. <https://www.bis.gov.in/wp-content/uploads/2022/08/Booklet-Guide-for-Using-NBC-2016.pdf> xxiii. <https://www.bis.gov.in/standards/technical-department/national-building-code/> xxiv. <https://law.resource.org/pub/in/bis/S03/is.sp.21.2005.pdf>
- xxv. <https://www.grihaindia.org/case-study> xxvi. <https://igbc.in/igbc-rating-systems.php>

## 15. PO-COMPETENCY-CO MAPPING

Semester IV	Construction Quality Control & Monitoring (Course Code: 4350602)									
	POs and PSOs									
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/development of solutions	PO 4 Engineering Tools, Experimentation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning	PSO 1	PSO 2	PSO 3

Competency	• Impart the fundamental skills and knowledge necessary to comprehend the practice of Construction Quality Control & Monitoring									
CO a.	3	-	-	2	3	3	3			
Total Quality Management (TQM) in Construction										
CO b. Construction Quality Control Inspection Program	3	2	-	2	3	3	3			
CO c. Statistical Quality Control & Monitoring	-	2	-	2	-3	2	3			
CO d. Quality Standards		2	1	2	1	2	3			
CO e. Green Building & Sustainable Construction Development	1		3	3	3	2	3			
CO f. Life Cycle Assessment for Building Products	1		3	2	2	2	3			

Legend: '3' for high, '2' for medium, '1' for low or '-' for the relevant correlation of each competency, CO, with PO/ PSO

## 16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

### GTU Resource Persons

S. No.	Name and Designation	Institute	Contact No.	Email

1	Shri. Rahul S. Oza	Government Polytechnic, Jamnagar	9426994979	rahuloza.engg@gmail.com
2	Shri. Rajiv B. Dabhi	Government Polytechnic, Jamnagar	9879669517	rajeev.dabhi@gmail.com