CE 3

The Undergraduate Programme in the Department of Civil Engineering at IIT Kanpur for the Decade 2011-2020

Recommendations of the Fifth Department Academic Review Committee

Department of Civil Engineering
IIT Kanpur

August, 2011

Table of Contents

1 Introduction

At the start of any review, the first question to be answered is why a review needed. Two very good and sufficient reasons for this review are: (i) it is customary to review the undergraduate program at IIT Kanpur every 10 years and all departments therefore, also must do it; (ii) in today's fast paced world, 10 years is a long time for any area of expertise (even for old areas like civil engineering). The committee therefore started out by identifying the guiding principles for an undergraduate program in civil engineering in the decade 2011-20. These can be listed as follows:

- Technological and socio-economic reality of India and its implication on the civil engineering education at IIT Kanpur, e.g., massive growth of infrastructure and service sector, increasing demand for interdisciplinary expertise, expanding higher education in general and technical education in particular, *niche* of an IIT Kanpur civil engineer in the ever-expanding pool of graduating engineers in India. Civil engineering curriculum at leading universities around the world and recommendations of independent committee reports[1] on civil engineering education serves as some of the reference points.

- Framework and limits set by the Academic Review Committee of IIT Kanpur.

Civil engineering as a discipline has travelled a long way since the building of pyramids and now encompasses a vast array of sub-disciplines some of which are as different from each other as civil engineering is from other engineering disciplines. During the evolution of civil engineering as a discipline, it has been linked with the knowledge of structures, mechanics, materials science, survey, geology, soil and foundation, environment and sanitation, hydrology, water resources, and transportation. As the knowledge in each of these areas expanded, they became established as sub-disciplines of civil engineering.

At the present time, it is not expected for an undergraduate student in civil engineering to have expertise in all the sub-disciplines. The society such as ASCE recommends proficiency in any of the four sub-disciplines for entry into the practice of civil engineering at the professional level[1] while recognizing the fact that an in depth knowledge (or expertise) in each of the disciplines can only be provided at the master's level. We envisage the graduates of civil engineering department at IIT Kanpur to be the leaders of the rapid economic progress and related infrastructure development in India (niche!). We imagine the students to be the driver rather than a cog in the wheel of rapid economic development. In order to achieve that, a student requires an overall perspective of the entire discipline along with social, economic and management aspects of civil engineering. Each student will also need the option of developing extra expertise on a few (2-4) of their chosen areas through appropriate electives. The student should have enough freedom to tailor their curriculum in such a way that all career options (e.g., industry, academia and management) remain open to them following their undergraduate degree.

One of the common criticisms from the students for the last several decades had been that the undergraduate program at IIT Kanpur was too heavily loaded. The ARC in its

[1] Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future, 2nd Ed., ASCE, 2008, Virginia, USA.

wisdom has reduced the academic load to a large extent as well as made an attempt to build more flexibility in the curriculum by increasing the electives.

Keeping in view the need and the spirit of the framework of ARC, the undergraduate program of Civil Engineering at IIT Kanpur for the decade 2011-20 has been designed. This document gives the detail of this proposed program.

2 Overview of the Proposed UG Structure for CE

The core of the undergraduate Civil Engineering program consists of 101 credits and the department electives consist of 40 credits. The core program imparts fundamental knowledge of all the sub-disciplines of civil engineering and design aspects of most common infrastructure related sub-disciplines such as, structure and foundation. The electives have been partitioned into two baskets. The Basket A is composed of five design courses from different sub-disciplines, each of 11 credits. Other department electives (including PG courses) and UG research makes the 2nd basket (Basket B). A student needs to collect at least 22 credits (2 courses) from the Basket A. The rest of the 18 credits can be picked from any of the two baskets and also through research. In addition to the department core and electives, we also propose a compulsory management course (under the management courses group in ARC recommendation) to introduce the students to the aspects of construction management which is highly relevant for infrastructure development projects. The traditional survey and geology camp has been made optional and the students interested in those areas can take that. The students with exceptional academic credentials, who may be interested in academia, have the option of taking a third undergraduate research for extra credits.

The flexibility to mix and match courses from different baskets gives a lot of flexibility to a student to tailor his/her program according to the career option and at the same time ensures that, each student graduating with an undergraduate degree in civil engineering has sufficient design credits in his/her kitty. For example, a student interested in pursuing a career in core civil engineering may take more design courses, or a student interested in specializing in a particular sub-discipline may take all the elective courses in that, or a student interested in research may take "UG Research" courses.

Let us first compare the existing core program with the proposed new core program from the point of view of student load. Since the concept of credit did not exist in the older program and the discussion hours cannot be mapped to an equivalent credit, contact hours appear to be a reasonable metric for comparison. A bar chart of such comparison is shown in Figure 1. In the new program, the lecture and laboratory contact hours have been reduced by similar proportions (~30%) while the hours of tutorial, discussion and others have completely disappeared. This leads to substantial decrease of the core contact hours for the students. In the older program, if the total classroom contact hours are assumed to be the sum of lectures and tutorials, in the new program it is reduced by 40%. The laboratory contact hours are reduced by 30%. Discussion hours were optional for the students and therefore, not counted towards the classroom contact hours. The hours in the "others" category are now either optional (Survey Camp) or can be taken as electives (UG Research) in Basket B. While there is a substantial reduction in the core program, the departmental electives remain approximately the same (4 courses) and number of open electives has increased (6 courses in place of 4). Therefore, the ratio of electives to core has

increased substantially which is a good indicator of the flexibility a student has to design his/her curriculum.

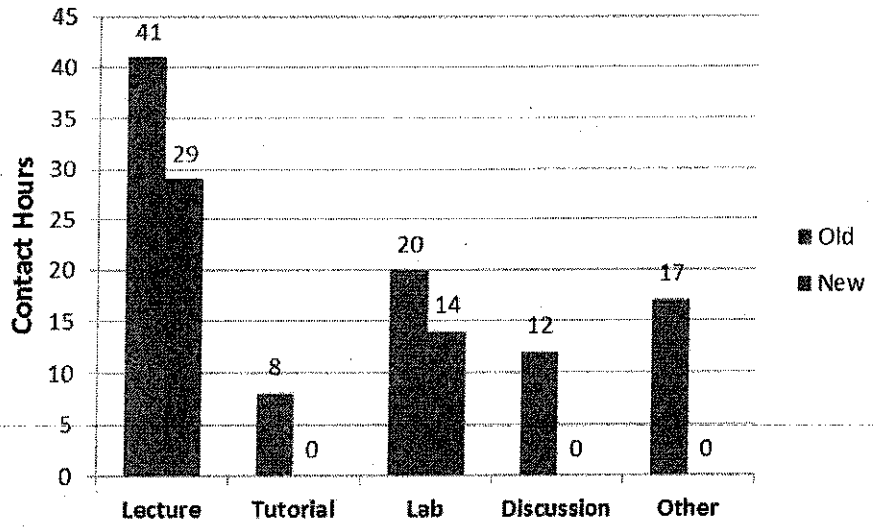

Figure 1: Comparison of the contact hours of the old (existing) and the new (proposed) program. The bar "other" consists of survey camp and B. Tech. Projects.

Let us now highlight a few salient features of the proposed curriculum. The contact hours of classroom and laboratory in the core program have an approximate 2:1 distribution (Figure 2). This ratio remains the same as the older program if one ignores the tutorial and discussion contact hours.

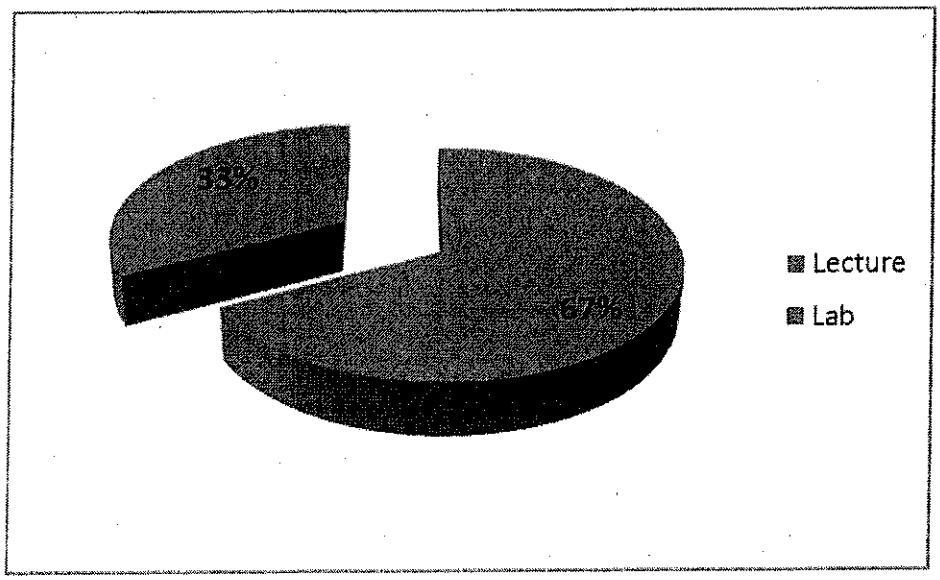

Figure 2: Proportion of the Lecture and Laboratory **contact hours** in the new (proposed) program.

For an engineering program, it is more appropriate to look at the distribution of theory, design and laboratory credits. This distribution for the core program is shown in Figure 3.

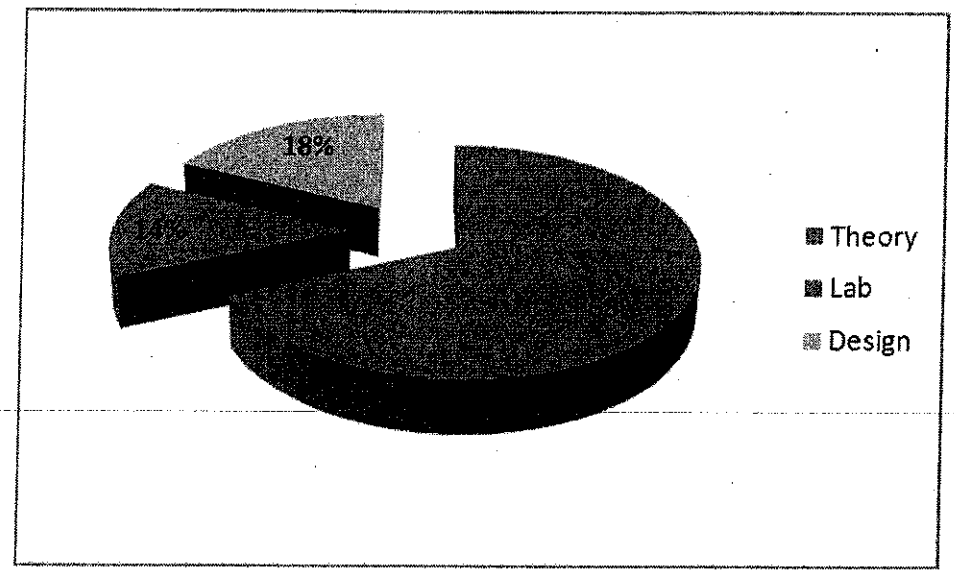

Figure 3: Proportion of the Theory, Design and Laboratory **credits** in the new (proposed) core civil engineering program. Total Credit = 100.

Minimum total civil engineering content of the curriculum consists of the core and the department electives. It is minimum because some of the open electives can also be taken from the department courses. The typical distribution of credits across different modes of learning (theory, design, laboratory and research) is shown for a few cases of plausible choices of electives:

- Minimum requirement of 2 courses taken from Basket A and two more courses taken from Basket B but the UG Research is not chosen. This is the likely case for an average student targeting generic industry as career option. Total CE credit = 141. (Figure 4a)

- All four electives are taken from Basket A. This is the likely case for students interested in specialization in the core CE area and targeting core CE industry as career option. Total CE credit = 145. (Figure 4b)

- Minimum requirement of 2 courses taken from Basket A and two UG research courses taken from Basket B. This is the likely case for a student interested in higher studies. Total CE credit = 141. (Figure 4c)

- Minimum requirement of 2 courses taken from Basket A and two UG research courses taken from Basket B. In addition, the UG Research extra credit option is also taken. This is the likely case for an exceptional student targeting academia or research as career option. Total CE credit = 150. (Figure 4d)

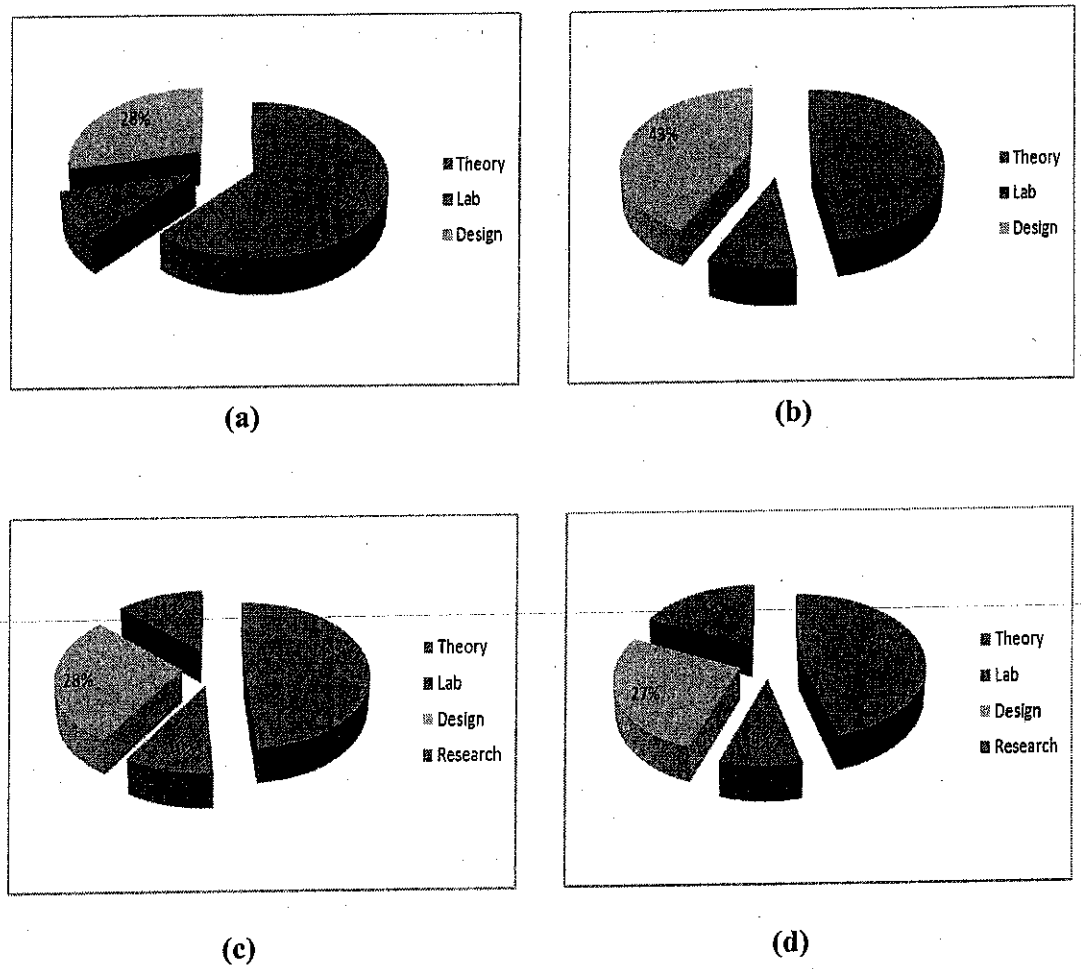

Figure 4: Proportion of the Theory, Design, Research and Laboratory **credits** in the new (proposed) civil engineering program for different combinations of elective options. (a) 2 courses from Basket A + 2 non research courses from Basket B, Total Credit = 141; (c) 2 courses from Basket A + 2 UG research courses from Basket B, Total Credit = 141; (d) 2 courses from Basket A + 2 UG research courses from Basket B + 1 extra credit UG Research course, Total Credit = 150.

The discussion so far about the new program can be summarized into the following points:

- The *breadth of knowledge* in civil engineering is imparted by the core program. The fundamentals of all the sub-disciplines, structural engineering (STR), geotechnical engineering (GTE), environmental engineering (EE), hydraulic and water resources (HWRE), transportation engineering (TE), engineering geosciences (EG), geoinformatics (GI) and materials science (GN) are included in the core credits. In addition, design of structure and foundation are also part of the core program.

- The choice of electives provides the students with flexibility to pursue any career options according to their interest.

In summary, the course attempts to prepare the students to be leaders in their field of interest by providing a broad range of fundamental background and at the same time, flexibility to specialize in a few select sub-disciplines. This is consistent with our first guiding principle.

It is now apt to compare the proposed program with the recommendation of ARC (2nd guiding principle). The ARC in its report (Table 1 of ARC report) has *elastically frozen* the guideline values for credit allocation across different segments in an academic program. The proposed curriculum of Civil Engineering is compared with the guidelines given by the academic review committee (ARC) in Table 1.

Table 1. ARC Guidelines for Percentage Credit Allocation in Academic Programme vis-à-vis Department Proposal

Course Group	Group Code[3]	CE Dept Credits (Min)	CE Dept, % of Total	ARC Reco, % of Total
HSS (excluding Management, comm. Skills etc)	HSS	49	11.8	10
Science (including electives)	S	75[1]	18.0	20
Engineering Science (ESc, ESO)	ES	61	14.7	10
Technical Arts	TA	20	4.8	5
Management + PE + Comm Skills + Foreign Language	MPCFL	16	3.8	5
Department Core (Mandatory)	DC	101	24.3	25
Department Elective	DE	40[2]	9.6	10
Open Elective	OE	54[2]	13.0	15
Total		**416**	**100**	**100**

[1]Does not include electives. Impossible to include as the students are free to choose them according to their wish.
[2]Minimum credits. May increase depending on the courses chosen by the student.
[3]These codes have been used in the template to identify the credit contributions.

2.1 Special Notes for the Credit Allocation

The Table 1 shows the minimum credit requirement for a student to graduate in the Department of Civil Engineering. Total credits may be higher, e.g., if a student takes the optional UGP-1 (Survey and Geology Camp) + UGP-4 (extra credits) + all 4 DEs from Basket A, total credit = 416+4+9+4 = 432.

There is no clarity in the ARC document about the MPCFL, neither there are separate slots for this in the master template. Availability of foreign language courses is limited. Since the minimum total credit is 416, there is space to add a foreign language course, as and when it becomes available.

Six open elective credits were calculated assuming typical courses of 9 credits (3 lectures per week). If some courses chosen by the student contain tutorials or laboratory, the credits will increase. In order to keep this flexibility, minimum credit was kept at somewhat lower level (13%).

3 Template for the CE Department

In an ideal credit-based system, a structured template is not relevant. However, academic consideration of pre-requisites often dictates that some courses cannot be taken unless the relevant background has been developed by completing the pre-requisites. This section shows an example (suggested!) template for a student in the department of civil engineering (Table 2) for the four year B.Tech. program. Structure of the courses are shown as the number of Lecture(L)-Tutorial(T)-Laboratory(P)-Assignment(A) per week.

Table 2. Civil Engineering Department Template for B.Tech. Program

First Semester			**Second Semester**		
S: MTH 101 (C)	3-1-0-0	11	**S:** MTH 102	3-1-0-0	11
S: PHY 103	3-1-0-0	11	**S:** PHY 102	3-1-0-0	11
S: CHM 101 (Lab)	0-0-3-0	03	**S:** PHY 101 (Lab)	0-0-3-0	03
TA: TA 101	2-0-3-0	09	**ES:** ESC 101	3-1-3-0	14
S: LIF 101	2-0-0-0	06	**S:** CHM 102	2-1-0-0	08
HSS: ENG 112/HSS-1 (Level 1)	3-1-0-0	11	**MPCFL:** PE102	0-0-3-0	03
MPCFL: PE101	0-0-3-0	03			
	Total	**54**		**Total**	**50**
Third Semester			**Fourth Semester**		
ES: ESC 201: Electronics	3-1-3-0	14	**HSS:** HSS-2 (Level 1)	3-1-0-0	11
ES: ESO-1: Mechanics of Solids	3-1-0-0	11	**S:** SO-3: Prob. & Stat	3-1-0-0	11
ES: ESO-2: Fluid Mechanics	3-1-0-0	11	**DC-2:** CE 242 CE Materials	3-0-2-0	11
DC-1: CE 211 Env Qual & Poll	3-0-3-0	12	**DC-3:** CE 272 Str. Analysis	3-0-0-0	09
TA: TA 201 (MSE)	1-0-3-0	06	**DC-4:** CE 262 Eng. Hydraulics	2-0-2-0	08
MPCFL: Composition (Web)	0-0-2-0	02	**TA:** TA 202 (ME)	1-0-3-0	06
	Total	**56**		**Total**	**56**
Fifth Semester			**Sixth Semester**		
ES: ESO-3: Numerical Methods	3-1-0-0	11	**DC-10:** CE 352 Fnd. Design	2-0-1-0	07
DC-5: CE 331 Geoinformatics	3-0-2-0	11	**DC-11:** CE 372 RCC Design	2-0-0-0	06
DC-6: CE 321 Engg Geosciences	2-0-2-0	08	**DC-12:** CE 382 Trans. Engg	3-0-0-0	09
DC-7: CE 351 Soil Mechanics	2-0-2-0	08	**HSS:** HSS-3 (Level 2)	3-0-0-0	09
DC-8: CE 371 Steel Design	2-0-0-0	06	**OE-1**	3-0-0-0	09
DC-9: CE 361 Engg. Hydrology	2-0-0-0	06	**OE-2**	3-0-0-0	09
MPCFL: Comm Skills	0-0-2-0	02	UGP-1: CE 332 (opt)	0-0-4-0	04
	Total	**52**		**Total**	**49(53)**
Seventh Semester			**Eighth Semester**		
MPCFL: CE 441: Const. Mgmt.	2-0-0-0	06	**DE(A) / DE(B)**		09/11
DE(A) / DE(B)		09/11	**DE(A) / DE(B) / OE-3**		09/11
DE(A) / DE(B) / OE-3		09/11	**OE-5**	3-0-0-0	09
DE(A) / DE(B)		09/11	**OE-6**	3-0-0-0	09
OE-4	3-0-0-0	09	**HSS:** HSS-5 (Level 2)	3-0-0-0	09
HSS: HSS-4 (Level 2)	3-0-0-0	09	UGP4: CE 494 (Extr Crd)	0-0-0-9	09
	Total	51-57		**Total**	**45-58**

3.1 Special Notes on the Template

1. Engineering Science and Science Options: The following are the options of the Department of Civil Engineering in this category:

ESO-1: Mechanics of Solids (ESO 204 of the existing program or equivalent).

ESO-2: Fluid Mechanics (ESO 212 of the existing program or equivalent)

ESO-3: Numerical Methods (ESO 218 of the existing program or equivalent)

SO-3: Probability and Statistics (ESO 209 of the existing program or equivalent). There was no category of existing courses under the SO and this course was traditionally given an *engineering science* number. We consider this under the *science* option like the other core courses from the department of mathematics and statistics which are considered to be the *science core*. This may require renaming or repositioning of the existing course.

2. UGP-1: Survey Camp (Optional) will be offered in the winter between 5th and 6th Semesters and the grade will be submitted with the 6^{th} semester.

3. Departmental Electives: A minimum of 40 credits must be collected through departmental electives. At least 22 of these 40 credits must come from Basket A. All departmental electives are divided into two baskets as follows:

Basket A or DE(A): Consists of five courses, one each from the following sub-disciplines: STR, GTE, EE, HWRE and TE. Each of the five courses in this basket will be of 11 credits. These five courses must be offered by the department every year. In the even semesters, two courses from EE and HWRE will be offered. In the odd semesters, three courses from STR, TE, and GTE will be offered.

Basket B or DE(B): Consists of UG Research I and II, UG electives offered by GI and EG, PG course on systems analysis, and PG courses that may be opened up for DE by any of the sub-disciplines. In addition to the UG research courses, it is expected that at least two courses in this basket will be available to the students in every semester.

4. UG Research: Two UG research courses CE 491 and CE 492 are available as department electives in Basket B and a third research course (CE 493) is available as extra credit. The following guidelines apply in order to register for research courses:

- The first research course taken by the student in DE(B) will be CE 491 irrespective of the semester (s)he is registering. Therefore, both the courses (CE 491 & CE 492) will be available to the students in all semesters. CE 492 has the pre-requisite of CE 491. Therefore, CE 492 is available to a student only if s(he) takes two research courses from the Basket B.

- Although, both the courses (CE 491 & 492) are available in all semesters in Basket B, a student is not allowed to register for both in the same semester.

- The extra credit research course is CE 493. It can be the only research course a student takes. However, a student requires a minimum CPI of 8.0 at the time of registration in order to take the extra load (credit).

- In order to register in any of the 3 research courses, the student need to identify an adviser. Advisers will ensure that the student has sufficient core and elective credits (pre-requisites) in order to carry out the proposed research. Advisers consent is required before the registration.

- For a student, the adviser(s) in 3 research courses can be different or same.

- A student is allowed to register for the extra credit course in conjunction with either CE 491 or CE 492 in the same semester.

3.2 Numbering of Courses

The numbering has been done as "CE *mnp*" where,

m = the year of the program in which a regular student takes the course in the suggested template. For compulsory courses, the year is according to the template (Table 2). For elective, optional and research courses, *m* = 4.

n = sub-discipline identifier. The sub-disciplines are arranged in an alphabetical order as follows: EE-1, EG-2, GI-3, GN-4, GTE-5, HWRE-6, STR-7, TE-8. For research and reading courses, *n* = 9.

p = an integer indicating the semester it is offered. *Odd* (1 ,3, ..) for odd semesters and *Even* (2, 4, ...) for even semesters. Only exceptions are UG research courses which may be offered in either semester. They are numbered sequentially.

3.3 Departmental Compulsory Courses

L-T-P-A	Credits	Title	Number
3-0-3-0	12	Environmental Quality and Pollution	CE211
3-0-2-0	11	Civil Engineering Materials	CE242
2-0-2-0	08	Engineering Hydraulics	CE262
3-0-0-0	09	Structural Analysis	CE272
2-0-2-0	08	Engineering Geosciences	CE321
3-0-2-0	11	Geoinformatics	CE331
2-0-2-0	08	Soil Mechanics	CE351
2-0-1-0	07	Foundation Design	CE352
2-0-0-0	06	Engineering Hydrology	CE361
2-0-0-0	06	Design of Steel Structures	CE371
2-0-0-0	06	Design of Reinforced Concrete Structures	CE372
3-0-0-0	09	Introduction to Transportation Engineering	CE382
	101	**Total**	

3.4 Compulsory Management Course

L-T-P-A	Credits	Title	Number
2-0-0-0	06	Construction Management	CE 441

3.5 Electives in Basket A

A minimum 22 credits is required from this basket.

L-T-P-A	Credits	Title	Number
3-0-2-0	11	Water Supply and Wastewater Disposal System	CE 412
3-0-0-2	11	Application of Geotechnical Engineering	CE 451
3-1-0-0	11	Hydraulic and Hydrologic Design	CE 462
3-0-0-2	11	Special Topics in Structural Design	CE 471
3-0-0-2	11	Transportation Facilities Design	CE 481

3.6 Electives in Basket B

No Minimum credit requirement from this basket. At least two courses in addition to the UG Research I and II will be made available to the students every semester.

L-T-P-A	Credits	Title	Number
3-0-0-0	09	Physical and Environmental Geology	CE 422
3-0-0-0	09	Advanced Measurement Techniques	CE 431
3-0-0-0	09	Civil Engineering Systems Analysis	CE 642A
0-0-0-9	09	UG Research I	CE 491
0-0-0-9	09	UG Research II	CE 492

Other PG Courses: as available from time to time.

3.7 Optional and Extra Credit Courses

L-T-P-A	Credits	Title	Number
0-0-4-0	04	Survey and Geology Camp (Optional)	CE 332
0-0-0-9	09	UG Research III (Extra Credits)	CE 493

4 Minor

Department of Civil Engineering will offer minor in the area of *Earth Sciences*. This minor will consist of a string of three courses: CE 322, CE 422 (section 3.6) and CE 642 (existing post graduate course). The minor will be open to all students other than the students in Civil Engineering. CE 322 is a course that will only be open to non-CE students since it has substantial overlap with CE 321. The course structure is given below:

L-T-P-A	Credits	Title	Number
3-0-0-0	09	Earth Sciences	CE322

5 Dual Major

Department of Civil Engineering recommends that a double major in CE is made open to the students of ME and AE. Curriculums of other existing departments are such that the students will lack many of the core requirements of the department of Civil Engineering and will not be able to complete the requirements of a dual degree in one extra year. The specific requirements for the AE and ME students to obtain a double major in CE will be formulated once the curriculum of these two programs are available.

The double majors that would be accessible to the students in civil engineering will be clear after the undergraduate curriculum and requirements of other departments are available.

6. B.Tech.-M.Tech. Dual Degree

For the five year B.Tech.-M.Tech. (BT-MT) dual degree, it is expected that a student will complete all the core requirements of the B.Tech. and M.Tech. This requires the students to complete 6-7 PG courses and two semesters of research credits in addition to the core B.Tech. requirements. In the proposed B.Tech. program, a student in CE will normally take 10 elective courses, 4 department electives and 6 open electives. In the dual degree program, we propose that the student takes 7 PG courses out of 10 electives. Other 3 are department electives two of which must come from Basket A (Section 3.5). The third elective may come from any of the two baskets but should not be the UG Research courses (in Basket B, section 3.6). Out of 7 PG courses, only one (CE 642A) is compulsory. The rest of the six courses must be chosen in consultation with the M.Tech. thesis adviser. A BT-MT dual degree student will choose (or be assigned) a thesis adviser by the end of the sixth semester and before the beginning of the 7th semester. A comparison of the credit requirements in different segments of BT and BT-MT dual degree are shown in Table 3.

Table 3. Comparison of Credit Allocation in BT and BT-MT dual degree

Course Group	Group Code	BT	BT-MT
HSS (excluding Management, comm. Skills etc)	HSS	49	49
Science (including electives)	S	75[a]	75[a]
Engineering Science (ESc, ESO)	ES	61	61
Technical Arts	TA	20	20
Management+PE+Comm Skills+Foreign Language	MPCFL	16	16
Department Core (Mandatory)	DC	101	101
Department Elective	DE	40[b]	31[b]
Open Elective	OE	54[b,c]	00
PG Core (Mandatory)	PGC	00	9
PG Courses	PG	00	54[d]
M.Tech. Thesis	TH	00	88[e]
Total		**416**	**504**

[a]Does not include electives. Impossible to include as the students are free to choose.
[b]Minimum credits. May increase depending on the courses chosen by the student.
[c]May include some PG Courses.
[d]These courses are not compulsory. These are to be chosen by the students in consultation with the thesis superviser. So, they are similar to open electives.
[e]Credit computation of M.Tech. Thesis has not been defined yet by the ARC. This assumes an equivalent of 4 course loads of 11 credits (3L+1T) each per semester.

A tentative template for this program is shown in Table 4. It will be finalized once the detailed guidelines for the dual degree program are available from the ARC.

Table 4. Civil Engineering Department Template for B.Tech.-M.Tech. Dual Degree Program

First Semester			Second Semester		
S: MTH 101 (C)	3-1-0-0	11	**S:** MTH 102	3-1-0-0	11
S: PHY 103	3-1-0-0	11	**S:** PHY 102	3-1-0-0	11
S: CHM 101 (Lab)	0-0-3-0	03	**S:** PHY 101 (Lab)	0-0-3-0	03
TA: TA 101	2-0-3-0	09	**ES:** ESC 101	3-1-3-0	14
S: LIF 101	2-0-0-0	06	**S:** CHM 102	2-1-0-0	08
HSS: ENG 112/HSS-1 (Level 1)	3-1-0-0	11	**MPCFL:** PE102	0-0-3-0	03
MPCFL: PE101	0-0-3-0	03			
	Total	**54**		**Total**	**50**
Third Semester			**Fourth Semester**		
ES: ESC 201: Electronics	3-1-3-0	14	**HSS:** HSS-2 (Level 1)	3-1-0-0	11
ES: ESO-1: Mechanics of Solids	3-1-0-0	11	**S:** SO-3: Prob. & Stat	3-1-0-0	11
ES: ESO-2: Fluid Mechanics	3-1-0-0	11	**DC-2:** CE 242 CE Materials	3-0-2-0	11
DC-1: CE 211 Env Qual & Poll	3-0-3-0	12	**DC-3:** CE 272 Str. Analysis	3-0-0-0	09
TA: TA 201 (MSE)	1-0-3-0	06	**DC-4:** CE 262 Eng. Hydraulics	2-0-2-0	08
MPCFL: Composition (Web)	0-0-2-0	02	**TA:** TA 202 (ME)	1-0-3-0	06
	Total	**56**		**Total**	**56**
Fifth Semester			**Sixth Semester**		
ES: ESO-3: Numerical Methods	3-1-0-0	11	**DC-10:** CE 352 Fnd. Design	2-0-1-0	07
DC-5: CE 331 Geoinformatics	3-0-2-0	11	**DC-11:** CE 372 RCC Design	2-0-0-0	06
DC-6: CE 321 Engg Geosciences	2-0-2-0	08	**DC-12:** CE 382 Trans. Engg	3-0-0-0	09
DC-7: CE 351 Soil Mechanics	2-0-2-0	08	**HSS:** HSS-3 (Level 2)	3-0-0-0	09
DC-8: CE 371 Steel Design	2-0-0-0	06	**PGC:** CE 642A Sys. Anal.	3-0-0-0	09
DC-9: CE 361 Engg. Hydrology	2-0-0-0	06	**DE(A) / DE(B)**		09/11
MPCFL: Comm Skills	0-0-2-0	02	**UGP1:** CE 332 (optional)	0-0-4-0	04
	Total	**52**		**Total**	**49-55**
Seventh Semester			**Eighth Semester**		
MPCFL: CE 441: Const. Mgmt.	2-0-0-0	06	**DE(A) / DE(B) / PG-2**		09/11
DE(A) / DE(B) / PG-2		09/11	**PG-5**	3-0-0-0	09
DE(A) / DE(B)		09/11	**PG-6**	3-0-0-0	09
PG-3	3-0-0-0	09	**PG-7**	3-0-0-0	09
PG-4	3-0-0-0	09	**HSS:** HSS-5 (Level 2)	3-0-0-0	09
HSS: HSS-4 (Level 2)	3-0-0-0	09	**UGP4:** CE 494 (Extra Credit)	0-0-0-9	09
	Total	**51-55**		**Total**	**45-56**
Ninth Semester			**Tenth Semester**		
TH: M.Tech. Thesis		44	**TH:** M.Tech. Thesis		44
	Total	**44**		**Total**	**44**

7. Outline of the courses

In the following pages, the detailed outlines of the proposed courses listed in section 3 are shown. The details of the elective PG courses in Basket B are not included in the document since they already exist. The Table 5 gives the pointer to the group of courses and their section numbers. In the details of the course, the pre-requisite section uses two terms, *Pass Grades* and *Exposure Grade.* A pass grade refers to any of *A*, A, B, C or D.* An exposure grade is *E.* The *F* is a fail grade and does not satisfy any of the pre-requisite.

Table 5: Detailed outline of the courses proposed in this document.

Course Group	Description In
Civil Engineering Core Program	7.1-7.12
Compulsory Management Course	7.13
Electives in Basket A	7.14-7.18
Electives in Basket B	7.19-7.23
Optional and Extra Credit Courses	7.24-7.25
Special Courses for Minor	7.26

7.1 CE 211: Environmental Quality and Pollution

Course Structure: 3L-0T-3P-0A (12 credits)
Pre-requisites: Any pass grades (A-D) in CHM 101 and MTH 101, at least an exposure grade in CHM 102 and LIF 101

Objective of the course: The course is designed to give the students a broad understanding of all issues related to environmental science, engineering and management, including practical training on pollution monitoring techniques.

Specialized Infrastructure requirement: Since the student strength in this course is ~100, lectures should only be scheduled in larger rooms, i.e., L16, L17 etc. In addition to the lectures, the course has a laboratory component where students get hands-on training (in groups of 2) in environmental quality and pollution monitoring techniques. Laboratory space requirement is 2 m^2 per student. Due to space constraints in the Environmental Engineering Laboratory, the laboratory classes are generally held in two sessions per week. Further increases in student strength over the last three years have made the space crunch more acute and the laboratory sessions may have to be held for 3 sessions / week in future. This will require enhanced faculty and staff involvement. Additional TAs must also be assigned to the course. The current yearly funds requirement (consumable purchases) for this laboratory is approximately Rs. 4000 per student. Funds for equipment purchase are also required on a yearly basis.

Instructional aspects: One hour per week laboratory instruction is required. Therefore, the 3 laboratory hours will be broken into 1+2. The instructions for the laboratory sessions would be given to the students in the first hour followed by the laboratory experiments.

Course content: Introduction and Scope; Ecology and Environment; Environmental Quality Parameters; Aquatic Chemistry; Mass Transfer; Particles in Environment; Pollutant Transport; Air Pollution; Environmental Modeling; Solid and Hazardous Waste Management; Environmental Impact Assessment;

Lecture-wise break-up:

S.No.	Topic	Description	Lectures
1.	Introduction and Scope	General concept of Environmental Engineering	1
2.	Ecology and Environment	Impact of pollution on the environment	2
3.	Environmental Quality Parameters	Various pollutants in different media, introduction to Environmental Standards, Brief mention of development of environmental standards	6
4.	Aquatic Chemistry	Acid-base chemistry, alkalinity, metal complexation, precipitation, etc	7
5.	Mass Transfer	Inter-media transfer of pollutants e.g. gas-liquid, solid-liquid transfers	3
6.	Particles in Environment	Formation, settling deposition, flocculation; attachment	2
7.	Pollutant Transport	Mechanisms of Pollutant Transport	2
8.	Air Pollution	Pollutant sources, effects, meteorology as applied to air pollution, air pollution control;	8
9.	Environmental Modeling	Pollutant transport equations; Development of analytical/ predictive environmental models for various environmental media	3
10.	Solid and Hazardous Waste Management	Definition; Control measures; Disposal of Wastes, Management	3
11.	Environmental Impact Assessment	Concept and importance; Various steps in a EIA study; assessment of impacts; mitigation of adverse impacts; Environmental management plan.	3
		TOTAL	**40**

Laboratory Sessions:

S.No.	Topic	Description	Lab hours
1.	Introduction to Environmental Engineering Laboratory	Tour of the laboratory; Familiarization with glassware, and instruments etc.	2
2.	Measurement of Water and Wastewater Quality Parameters	Alkalinity, pH, solids, anions, cations, BOD, COD, TKN, P, microbial quality, etc.	14
3.	Demonstration of Air Pollution Measurement Instrumentation	Ambient particle and gaseous samplers, stack monitoring,	4

		meterology, etc.	
4.	Demonstration of Advanced Analytical Instrumentation	Gas and liquid chromatographs, measurement of metals, organic carbon analyzers, and other advanced instruments in Environmental Engineering laboratory	4

Suggested Text and Reference Materials:

Text Book:

Environmental Engineering Science. Authors: William W. Nazaroff and Liza Alvarez-Cohen. Publisher: John Wiley and Sons (Indian Edition Available).

Reference Books:

Chemistry for Environmental Engineering and Science. Authors: Clair N. Sawyer, Perry L. McCarty and Gene F. Parkin. %th Edition (2003). 1st Edition (2001). Publisher: Tata McGraw-Hill (Indian Edition Available).

Standard Methods for Examination of Water and Wastewater. Editors: APHA, WEF, AWWA. 19th Edition (1995). Publisher: APHA, Washington D.C.

Additional class notes and reference material will be provided during lectures, either in softcopy or hardcopy forms. A hardcopy laboratory manual will also be made available.

Main differences suggested in this review:

The course is largely unchanged from its previous form. However, henceforth this will be the only compulsory course on Environmental Engineering in the B. Tech. Civil Engineering syllabus at IIT Kanpur.

7.2 CE 242: Civil Engineering Materials

Course Structure: 3L-0T-2P-0A (11 credits)
Pre-requisites: None

Objective of the course: The course is designed to familiarize the students with important construction materials, especially cement and concrete, steel, and bitumen. The course will also introduce the students to the use of soil as a construction material, and some new materials such as the fibre-reinforced plastics, epoxy coated reinforcements, etc.

Specialized Infrastructure requirement: In addition to the lectures, the course will involve laboratory work in all areas over 12 sessions to be held in the Structural, Geotechnical and the Transportation laboratories of the Department.

Instructional aspects:

a) It is preferable that the Laboratory sessions are NOT scheduled on a Friday or on a Monday.
b) The course will not have any prerequisites.

Course content: Properties of construction material and their evaluation (creep, elastic modulus, fatigue, impact, etc.); test methods and specifications; Cement – chemical composition, properties such as setting, strength, fineness, hydration; Aggregates – sources, properties, chemical reactivity; Concrete - constituents, proportioning, properties in fresh and hardened state, characteristic strength, quality control (sampling, acceptance, etc.), transportation and placing, testing (including NDT), porosity; Admixtures – chemical, mineral; Steel – properties, types of steel, steel in civil engineering; Bricks – manufacture, properties and classification; masonry bonds; New materials – Fibre reinforced plastics (FRPs), epoxy-coated bars, etc. with performance requirements, test methods, specifications; Bitumen – source, composition, characterization, various forms, tests on bitumen; Bituminous mix design; Soil – description, engineering geology of soils and their formation, index properties of soil, classification of soils.

Lecture-wise break-up:

Topic	Number of lectures
Properties of material and their evaluation (creep, elastic modulus, fatigue, impact, etc.); test methods and specifications;	3
Chemical composition, properties – setting, strength, fineness, hydration;	4
Sources, properties, chemical reactivity;	1
Constituents, proportioning, properties of fresh and hardened concrete, characteristic strength, quality control (sampling, acceptance, etc.), transportation and placing, testing (including NDT), porosity;	8
Chemical, mineral;	2
Properties, types of steel, steel in civil engineering;	3
Introduction to manufacture, properties and classification; masonry bonds;	2
Basic concepts of Fibre reinforced plastics (FRPs), composition and properties and applications of FRPs in civil engineering;	3
Illustrative examples such as epoxy-coated bars, etc. with performance requirements, test methods, specifications.	4
Bitumen: Source, composition, characterization, various forms, tests on bitumen; Bituminous mix design;	6
Description of soil, engineering geology of soils and their formation, index properties of soil, classification of soils;	6
Total Lectures	**42**

Laboratory Sessions

1	**Soil**	Specific gravity analysis and Atterberg limits
2		Sieve and hydrometer analysis
3		California Bearing Ratio
4	**Bitumen**	Penetration, softening point, ductility of bitumen
5	**Steel**	Tensile testing of steel

6	**Aggregate**	Mechanical properties of coarse aggregates (aggregate crushing value, aggregate impact value, aggregate abrasion value)
7		Physical properties of coarse and fine aggregates (particle size distribution, fineness modulus, water absorption, bulk density & specific gravity)
8	**Cement**	Standard consistency and initial and final setting times of cement
9		Specific gravity, fineness, soundness & compressive strength of cement
10	**Concrete**	Properties of fresh and hardened concrete
11	**Bricks**	Dimensions, water absorption, compressive strength & efflorescence of bricks
12	**Mineral and chemical admixtures**	(a) Effect of chemical admixture addition on consistency of cement paste & setting time of cement (b) Effect of mineral admixture addition and water cement ratio on strength of cement mortar
Total number of laboratory sessions: Twelve (12)		

Suggested text and reference material

- Materials of Construction – GD Taylor, Prentice Hall
- Concrete – Material, Microstructure and Properties, PK Mehta and PMJ Montiero, (Tata Mcgraw Hill)
- Relevant IS codes for testing and specifications
- Concrete Technology – ML Gambhir (Tata Mcgraw Hill)
- Concrete Technology, Neville and Brooks, ELBS/Longman
- Properties of Concrete, 4th Edition, Neville, ELBS/Longman
- Brick and Reinforced Brick Structures, P Dayaratnam, Oxford and IBH
- Construction Materials, D N Ghose, (Tata Mcgraw Hill)
- Highway engineering, Khanna and Justo, (Khanna Publishers, Delhi)
- Principles of transportation engineering, Chakraborty and Das, Prentice Hall of India
- Das BM., Advanced Soil Mechanics., 2008, Taylor and Francis, New York, USA.
- Lambe TW., and Whitman RV., Soil Mechanics., 2000, John Wiley and Sons (Asia), Singapore.

Main differences suggested in this review:

(1) The curriculum, including the experiments to be carried out during the laboratory session has been revised to reflect recent changes in use of construction materials and the technology.

(2) Some concepts of characterization of soil as a construction material have been added to this course and the overall content revised accordingly.

7.3 CE262: Engineering Hydraulics

Course Structure: 2L-0T-2P-0A (8 credits)

Pre-requisites: at least an exposure grade in ESO-2 (Fluid Mechanics)

Objective of the course: This course is designed as a compulsory course to acquaint an undergraduate student in Civil Engineering at IIT Kanpur with the fundamentals of hydraulics.

Specialized Infrastructure requirement: Laboratory facilities with multiple sets of experiments to accommodate a large batch of students.

Instructional aspects: It will involve some experiments related to hydrology.

Course content: Introduction. Review of the basic equations: continuity, momentum, and energy. Flow through closed conduits: Laminar flow, Turbulent flow, Pipes in Series and Parallel, Pipe Networks, Unsteady flow. Flow through open channels: Uniform flow, Critical flow, Gradually Varied flow, Rapidly Varied flow, Spatially Varied flow, Unsteady flow. Flow Measurement: Pressure, Velocity and Discharge measurements. Forces on immersed bodies: Drag and Lift. Basics of Irrigation Engineering: Crop water requirements, Irrigation methods.

Lecture-wise break-up:

S. No.	Topic	Suggested No. of Lectures
1	Introduction. Review of the basic equations : continuity, momentum, and energy	02
2	Flow through closed conduits: Laminar flow, Turbulent flow, Pipes in Series and Parallel, Pipe Networks, Unsteady flow	09
3	Flow through open channels: Uniform flow, Critical flow, Gradually Varied flow, Rapidly Varied flow, Spatially Varied flow, Unsteady flow	09
4	Flow Measurement: Pressure, Velocity and Discharge measurements	03
5	Forces on immersed bodies: Drag and Lift	02
6	Basics of Irrigation Engineering: Crop water requirements, Irrigation methods	02
	Total Lectures	**27**

Laboratory Sessions:

Session	Name of Experiment
1	Momentum equation: Impact of a jet
2	Energy Equation: Verification of Bernoulli's theorem
3	Friction losses in pipes
4	Minor losses in pipe fittings
5	Pipes in series and parallel
6	Hydraulic jump in open channels
7	Flow measurement: In pipes, using Venturi meter and orifice meter
8	Flow measurement: In open channels, using weirs
9	Forces on immersed bodies: Fall velocity
10	Unsteady flow in pipes: Water Hammer
11	Rainfall-runoff simulator
Total number of laboratory sessions: 11	

Suggested text and reference material:

1. Fox, R.W., and McDonald, A.T. (1996). Introduction to Fluid Mechanics, John Wiley.

2. Srivastava, R. (2008). Flow through Open Channels, Oxford University Press.

3. Asawa, G.L. (2005). Irrigation and Water Resources Engineering, New Age International Ltd.

Main differences suggested in this review:

The earlier course consisted of three lectures per week and this course consists of two lectures per week. Therefore, the width and depth of the course have been reduced. Some material covered in ESO212 was repeated in this course, which has now been removed. Potential flow has been moved to the elective course and most of irrigation engineering is also moved there.

7.4 CE 272: Structural Analysis

Course Structure: 3-0-0-0 (9 credits)
Pre-requisites: Pass grades in ESO-1 (Mechanics of Solids)

Objective of the course: This course is designed to cover principles of design of determinate and indeterminate structures.

Specialized Infrastructure requirement: None.

Instructional aspects: Mechanics of solids is a **prerequisite** for this course.

Course content: Stability and Determinacy of Structures, Review of shear force and bending moment diagrams in beams and frames, Plane trusses: method of joints and method of section, Deflection of trusses: method of virtual work, Deflection of beams and frames: moment-area method, conjugate beam method, method of virtual work, Influence line diagrams and moving loads, Force and stiffness methods of analysis, Plane trusses by using method of consistent deformations, Beams and frames: method of consistent deformations, slope-deflection equation, moment distribution method, Plane trusses and beams by using direct stiffness method

Lecture-wise break-up:

No	Item	Lectures	Topics
1	General	2	Stability and Determinacy of Structures
2	Analysis of Statically Determinate Structures	2	Review of shear force and bending moment diagrams in beams and frames
		2	Plane trusses: method of joints and method of sections
		2	Deflection of trusses: method of virtual work
		5	Deflection of beams and frames: moment-area method, conjugate beam method, method of virtual work
		4	Influence line diagrams and moving loads
3	Analysis of	1	Force and stiffness methods of analysis
	Statically	2	Plane trusses by using method of consistent

	Indeterminate Structures	2	deformations
		16	Beams and frames: method of consistent deformations, slope-deflection equation, moment distribution method
		6	Plane trusses and beams by using direct stiffness method
Total		42	

Suggested text and reference material:

1	TEXT	Norris, C.H., Wilbur, J.B., and Utku, S., Elementary Structural Analysis, McGraw Hill
2		Hibbeler, R. C. (2002). Structural Analysis, 6/e, Pearson Education
3	REFERENCE	Hsieh, Y., Elementary Theory of Structures, Prentice-Hall
4		Sack, R.L. (1989) Matrix Structural Analysis, Waveland Press, Inc.
5		Wang, C.K., Intermediate Structural Analysis, McGraw-Hill
6		Wang, C.K., Statically Indeterminate Structures, McGraw-Hill
7		West, H.H., Analysis of Structures, John Wiley

Main differences suggested in this review:

The curriculum has been suitably revised learning from the experience of teaching this course over the last several years.

7.5 CE 321: Engineering Geosciences

Course Structure: 2L-0T-2P-0A (8 credits)
Pre-requisites: None

Objective of the course: The course introduces the student to basic principles of geosciences and their applications in civil engineering.

Specialized Infrastructure requirement: In addition to the lectures, the course will have laboratory sessions linked to the lectures. Keeping in view a large number of students, the current space is inadequate.

Instructional aspects: A minimum of two batches will be required for running the laboratory sessions even after the provision of adequate space.

Course content: Introduction to geosciences in civil engineering, Plate tectonics (Continental drift, sea-floor spreading, types of plates and plate motion); Introduction to rock forming minerals (silicate structure, physical and chemical properties of minerals); Igneous, sedimentary and metamorphic rocks (texture; engineering properties); Geological Structures (fold, fault, joint, unconformity; engineering applications); Seismology and Earthquakes, magnitude and intensity, seismic hazard, earthquake prediction; Types of mass wasting events; Geological time scale and principles of stratigraphy; Weathering and soil formation; Surface processes and

landforms (rivers, coastal, and groundwater), Environmental geology; Geology of India, Criteria for site selection of dams, tunnels, waste disposal.

Lecture-wise break-up:

Topic	Suggested number of lectures
Introduction to geosciences in civil engineering	1
Plate Tectonics and continental drift	1
Rock-forming Minerals and their properties	3
Rock types and their engineering properties	3
Geological structures and engineering applications	4
Seismology and the internal structure of the earth	3
Mass wasting and slope processes	1
Geological time-scale and stratigraphy	2
Weathering and soil formation	1
Surface processes and landforms	4
Environmental geology	2
Geology of India	1
Civil Engineering applications – geological considerations in dams, tunnels and waste disposal	2
Total number of lectures	**28**

Laboratory Sessions:

Sessions	Name of Experiment
1	Interior of Earth, plate tectonics and sea-floor spreading
2	Identification of minerals in hand specimens; physical & chemical characteristics
3	Study of crystal forms/habits
4	Igneous rocks in hand specimens; texture, structure and origin of rocks
5	Sedimentary and metamorphic rocks; texture, structure and origin of rocks
6	Strike and dip using models and numerical problems
7	Interpretation of geological maps
8	Topographic maps and construction of topographic profile
9	Preparing geological cross-section
10	Seismology: Locating epicenter of Earthquake using p- and s-wave arrival times
11	Geomorphology
12	Geophysical methods
Total number of laboratory sessions: 12	

Suggested text and reference material:

- Understanding Earth (5th edition) by Grotzinger, Jordan, Press and Siever, Freeman and Company.
- Geology Applied to Engineering by Terry West, Prentice Hall.
- Dynamic of Earth by Skinner and Porter
- Structural Geology by M. P. Billings
- Essentials of Geology by Frederick Lutgens

Main differences suggested in this review:

- Lecture hours have been reduced from 42 to 28 hrs. Few advanced topics (e.g. climate change and environment) have been removed from here and included in CE 422.
- Topics are selected which have direct relevance to civil engineers.

7.6 CE 331: Geoinformatics

Course Structure: 3L-1T-3P-0A (11 credits)
Pre-requisites: None

Objective of the course: The course prepares the student to be able to understand basics of Land Surveying so they are ready to execute mapping and setting out projects.

Specialized Infrastructure requirement: Besides lectures and discussion hour the course needs exposure of students to the various laboratory instruments. It is desired to have one set of laboratory equipment among 5 students for optimizing learning. These instruments are total station, GPS, Levels, CAD and GIS software.

Instructional aspects: It is preferable that the tutorial should be on a Friday so that working examples, case studies can be shown to students which are related to what has been taught in the week.

Course content: Basic concepts of surveying-basic measurements and errors in measurements; Linear measurements-Tape, EDMI, Optical; Angle measurements-fundamental of Theodolite, adjustment; Vertical control-level surfaces, methods of levelling, contouring; Coordinate systems and datum transformation-Geoid, MSL, reference systems, transformation, map projection; Control surveys-traverse, triangulation, trilateration; Errors and adjustment-least squares adjustment; Total station survey-features and their use; GPS survey-basics and survey methods; Construction surveys-setting out civil engineering structures.

Lecture-wise break-up:

Topic	Suggested number of lectures
Basic concepts of surveying-Objectives; Basic measurements, control networks, locating topographic details; Units of measurement; Error in measurement and their types, indices of precision, weight, outliers; Error propagation	5

Linear measurements-Taping; Optical distance measurement; Electronic distance measurement, classification and calibration; Errors in distance measurement and precautions	4
Angle measurements-Concept of direction, azimuth, meridian; Theodolite, fundamental characteristic of theodolite and adjustment, measuring angles, sources of error	3
Vertical control-Level surface; Levelling principles, determination of height, leveling instruments; Sources of error and minimization, curvature and refraction effects; closure tolerances; Types of levelling; Characteristics of contours; methods of contouring	5
Coordinate systems and datum transformation-Important surfaces in geodesy: earth surface, geoid, MSL, reference ellipsoid; Reference systems: 2D and 3D coordinate systems and transformations; map projection, UTM projection	4
Control surveys-Traversing, Triangulation, Trilateration, and Triangulateration: types, field procedure, error minimization	4
Errors and adjustments-Sources of errors; types; accuracy and precision, propagation of variance/covariance and adjustment of errors using observation equation and condition equation approach (matrix-based solution)	5
Total station surveys-Principles, classification, salient features of total station	2
GPS surveys-Principles, errors, DGPS, DOP, GPS survey methods and planes	5
Construction surveys-Principle of setting out; Special instruments for setting out; Setting out a building, Setting out a highway curve	5
Total number of lectures	**42**

Laboratory Sessions:

Sessions	Name of Experiment
1	Sketching a map and understanding symbols
2	Introduction to map reading and numbering system
3	Calibration of EDMI and distance measurement
4	Theodolite angle measurement and testing
5	Fly levelling, level net
6	Theodolite traverse and trigonometric leveling
7	Total station Surveys (control establishment and detail plotting)-I
8	Total station Surveys (control establishment and detail plotting)-II
9	Total station Surveys (control establishment and detail plotting)-III
10	GPS surveys (control establishment and detail plotting)-I
11	GPS surveys (control establishment and detail plotting)-II
12	Setting out building

13	Setting out highway curve
Total number of laboratory sessions: 13	

Suggested text and reference material:

- Schofield, W, *Engineering Surveying*, Butterworth Heinemann, Oxford
- K. R. Arora, *Surveying*, Standard Book House, Delhi
- B. C. Punamia, *Surveying*, Standard Book House, Delhi
- P. R. Wolf and C. D. Ghilani, *Adjustment Computations*, John Wiley, NY
- K. K. Rampal, *Textbook of Photogrammetry*, Oxford & IBH Publishing, New Delhi
- Paul Wolf, *Elements of Photogrammetry*, McGraw Hill, Singapore (ISE)

Main differences suggested in this review:

- The course has been updated by removing about-to-obsolete technologies and including the latest technologies and techniques being pursued and researched.
- A new topic on Construction Surveys has been included in the course to give students complete picture of what a Civil Engineer is expected to perform in field.
- More lectures and laboratory exercises added to total station, as total stations and related techniques have advanced manifold in last decade.

7.7 CE 351: Soil Mechanics

Course Structure: 2L-0T-2P-0A (8 credits)
Pre-requisites: at least exposure grades in CE 242 and ESO-1 (Mechanics of Solids)

Objective of the course: The course prepares the student to be able to make effective learning of basic soil mechanics, laboratory experiment related to soil mechanics.

Specialized Infrastructure requirement: In addition to the lectures, the course is associated with a laboratory session. A group of four students can conduct experiment effectively. More space about 4 to 5 times of present lab space is required.

Course content: Stresses within a soil, effective stress principle, stress point and stress path, Soil - water systems- capillarity, flow, Darcy's law, permeability, and tests for its determination, different heads, piping, quicksand condition, seepage, flow nets, Compressibility and consolidation characteristics, Strength and direct and triaxial shear tests, Mohr - Coulomb strength criterion, drained, consolidated undrained and undrained tests, strength of loose and dense sands, NC and OC soils, dilation, pore pressures, Skempton's coefficients, etc. Compaction characteristics, water content - dry unit weight relationships, OMC, max. dry unit weight, field compaction control, etc.

Lecture-wise break-up:

Topic	Suggested Number of lectures

Stresses within a soil, effective stress principle, stress point and stress path, Soil - water systems- capillarity, flow	4
Darcy's law, permeability, and tests for its determination, different heads, piping, quicksand condition, seepage, flow nets	6
Compressibility and consolidation characteristics	4
Strength of loose and dense sands, NC and OC soils, dilation, pore pressures, Skempton's coefficients, etc.	10
Compaction characteristics, water content - dry unit weight relationships, OMC, max. dry unit weight, field compaction control, etc.	2
Total number of lectures	**26**

Laboratory Sessions:

Sessions	Name of Experiment
2	Field density; sand replacement and core cutter
2	Permeability; constant and variable test
1	Direct shear test
3	Triaxial test (UU, CU)
3	Consolidation tests (Loading and unloading)
Total number of laboratory sessions: 11	

Suggested text and reference material:

Craig RF., Craig's Soil Mechanics., 2004, Taylor and Francis, New York, USA.

Das BM., Advanced Soil Mechanics., 2008, Taylor and Francis, New York, USA.

Lambe TW., and Whitman RV., Soil Mechanics., 2000, John Wiley and Sons (Asia), Singapore.

Main differences suggested in this review:

(1) Introduction to soil mechanics and basic soil classification tests have been included in CE242 course (materials).

(2) Two lectures hours per week has been recommended in this course.

(3) The prerequisite of this course is CE242 (materials).

7.8 CE 352: Foundation Design

Course Structure: 2L-0T-1P-0A (7 credits)
Pre-requisites: Pass grades in CE 351

Objective of the course: The course prepares the student to be able to make effective learning of design of foundation, soil exploration and in-situ tests.

Specialized Infrastructure requirement: In addition to the lectures, the course is associated with a laboratory session. A group of four students can conduct experiment effectively. More laboratory equipments are required.

Course content: Site investigations, methods of drilling, sampling, in situ test - SPT, CPT, plate load and dynamic tests, groundwater level, etc. Bearing capacity, general, local and punching shear failures, corrections for size, shape, depth, water table, compressibility, etc., ultimate and allowable stresses, methods based on in situ tests, Settlements of foundations, stress in soils (Boussinesq, Westergaard), Design of foundation, Types of foundations - shallow/deep, isolated, combined, mat, etc., contact pressure distributions, Earth Pressure theories, Coulomb and Rankine approaches, c-ϕ soils, smooth and rough walls, inclined backfill, Deep foundations: pile and well foundations.

Lecture-wise break-up:

Topic	Suggested number of lectures
Site investigations, methods of drilling, sampling, in situ test - SPT, CPT, plate load and dynamic tests, groundwater level	4
Bearing capacity, general, local and punching shear failures, corrections for size, shape, depth, water table, compressibility, etc., ultimate and allowable stresses, methods based on in situ tests	6
Settlements of foundations, stress in soils (Boussinesq, Westergaard)	4
Design of foundation, Types of foundations - shallow/deep, isolated, combined, mat, etc., contact pressure distributions	4
Earth Pressure theories, Coulomb and Rankine approaches, c-ϕ soils, smooth and rough walls, inclined backfill	4
Deep foundations: pile and well foundations.	4
Total number of lectures	**26**

Laboratory Sessions:

Sessions	Name of Experiment
1	Standard Penetration test
1	Cone Penetration test
1	Pressure meter test
1	Plate Load test
2	Boring & Dynamic penetration test
Total number of laboratory sessions: 06	

Suggested text and reference material:

Craig RF., Craig's Soil Mechanics., 2004, Taylor and Francis, New York, USA.

Das BM., Principles of Geotechnical Engineering., 2007, Thomson, India.

Bowles JE., Foundation Analysis and Design., 1997, McGraw-Hill Co., Singapore.

Main differences suggested in this review:

(1) Introduction to Ground Improvement Techniques, Slope Stability Analysis, Flexible and Rigid retaining walls have been removed from the Course.

(2) One laboratory hours per week has been recommended in this course.

(3) Basic foundation design has been included.

7.9 CE 361: Engineering Hydrology

Course Structure: 2L-0T-0P-0A (6 credits)
Pre-requisites: None

Objective of the course: This course is designed as a compulsory course to acquaint an undergraduate student in civil engineering with the fundamentals of hydrology.

Specialized Infrastructure requirement: None

Instructional aspects:

Course content: Hydrologic cycle, water budget, world water quantities; Precipitation and Abstractions: Forms of precipitation, data analysis, rain-gauge networks; Infiltration - process, infiltration indices and Horton's equation; Evaporation and Evapotranspiration – Pan evaporation, empirical equations for estimating evaporation and evapotranspiration; Transpiration; Runoff and Hydrographs: Rainfall runoff relations, time area concept, flow duration curve, mass curve, flow hydrograph, Unit Hydrograph (UH), its analysis, S-curve hydrograph; Floods and Routing: Concepts of return period, flood frequency analysis, Gumbel's and Log-Pearson Type-III distributions, Rational method, risk, reliability, and safety factor; Hydrologic storage routing; Groundwater Hydrology: Types of aquifers and properties, Darcy's law, steady flow in a confined and unconfined aquifer (without recharge), steady flow to a well

Lecture-wise break-up:

S. No.	Topic	Suggested No. of Lectures
1	Introduction: Hydrologic cycle, water budget, world water quantities	01
2	Precipitation and Abstractions: Forms of precipitation, data analysis, rain-gauge networks; Infiltration - process, infiltration indices and Horton's equation; Evaporation and Evapotranspiration – Pan evaporation, empirical equations for estimating evaporation and evapotranspiration; Transpiration	06
3	Runoff and Hydrographs: Rainfall runoff relations, time area concept, flow duration curve, mass curve, flow hydrograph, Unit Hydrograph (UH), its analysis, S-curve hydrograph	07
4	Floods and Routing: Concepts of return period, flood frequency analysis, Gumbel's and Log-Pearson Type-III distributions,	07

	Rational method, risk, reliability, and safety factor; Hydrologic storage routing	
5	Groundwater Hydrology: Types of aquifers and properties, Darcy's law, steady flow in a confined and unconfined aquifer (without recharge), steady flow to a well	06
	Total Lectures	**27**

Suggested text and reference material:

1. Engineering Hydrology by K. Subramanya, Tata McGraw Hill, New Delhi.
2. Applied Hydrology by V. T. Chow, David Maidment, and Larry Mays, Tata McGraw Hill, New Delhi, India.

Main differences suggested in this review:

The earlier course consisted of three lectures per week and this course consists of two lectures per week. Therefore, the width and depth of the course have been reduced.

7.10 CE 371: Design of Steel Structures

Course Structure: 2-0-0-0 (6 credits)
Pre-requisites: Pass grades in ESO-1(Mechanics of Solids)

Objective of the course: This course is to serve as an introduction to the concepts of structural steel design through the use of the Indian Standard IS 800 design code. It deals the concepts of structures through the design of individual members and connections, such as, the design of tension members, compression members, beams, and beam columns; and bolted, welded, and connections. The primary course objective is to equip the students with the tools necessary for designing steel structures and to familiarize them with the relevant national design codes..

Specialized Infrastructure requirement: none.

Instructional aspects: Mechanics of solids is a **prerequisite** for this course.

Course content: Steel structures, Limit states and design philosophy; partial safety factors and load combinations; Analysis and design methods; Design of tension members based on net section including shear lag effects, staggered holes and block shear; Design of compression members for flexural and flexural-torsional buckling, Column formula, Local buckling and buckling class, End restraints and effective length factor; Role of plate buckling, Plastic hinge, Classification of section: plastic, compact, semi-compact, slender, Design strength of laterally supported beams, Shear buckling strength- Post-critical method, Shear-moment interaction, Design strength of laterally unsupported beams, Lateral torsional buckling, Effect of restraints and effective length; Effect of axial load on flexure behaviour, Cross-section yielding and member instability, P-M interaction and moment amplification, Bi-axial bending; Design of Bolts and Welds, Strength under combined stresses, Prying action, Common simple and eccentric joints and frame connections, Column bases.

Lecture-wise break-up:

No	Item	Lectures	Topics

1	General:	2	Steel structures, Limit states and design philosophy; partial safety factors and load combinations; Analysis and design methods
2	Tension Members	4	Design of tension members based on net section including shear lag effects, staggered holes and block shear
3	Compression Members	6	Design of compression members for flexural and flexural-torsional buckling, Column formula, Local buckling and buckling class, End restraints and effective length factor
4	Flexural members: Beams	8	Role of plate buckling, Plastic hinge, Classification of section: plastic, compact, semi-compact, slender, Design strength of laterally supported beams, Shear buckling strength- Post-critical method, Shear-moment interaction, Design strength of laterally unsupported beams, Lateral torsional buckling, Effect of restraints and effective length
5	Beam-Columns	3	Effect of axial load on flexure behaviour, Cross-section yielding and member instability, P-M interaction and moment amplification, Bi-axial bending
6	Connections	5	Design of Bolts and Welds, Strength under combined stresses, Prying action, Common simple and eccentric joints and frame connections, Column bases
		28	**Total**

Suggested text and reference material:

1	TEXT	Subramanian, N. (2008). Design of Steel Structures, Oxford University Press.
2		Bhavikatti, S. S. (2010). Design of Steel Structures (by Limit State Method as Per IS: 800—2007), IK International.
3	REFERENCE	Segui, W.T. (2007). Design of Steel Structures, Cengage Learning

Main differences suggested in this review:

The content of the course has been redesigned to deliver the absolute minimum that a civil engineer is expected to know. It is expected that some of the students will augment their understanding of the subject through appropriately designed elective courses.

7.11 CE 372: Design of Reinforced Concrete Structures

Course Structure: 2-0-0-0 (6 credits)

Pre-requisites: Pass grades in ESO-1 (Mechanics of Solids), at least an exposure grade in CE 242

Objective of the course: To expose and train the students for basic understanding in the behavior of reinforced concrete structures/members in the context of their design predominantly under the frame work of Indian Codes of Practice and any possible extensions.

Specialized Infrastructure requirement: No

Instructional aspects:

a) Mechanics of solids is a **prerequisite** for this course.
b) An 'E' grade in CE 242 is a **prerequisite** for this course.

Course content: Reinforced concrete (RC) structures, Loadings, analytical models for analysis and design of RC structures, Design Methodologies: Working Stress Method and Limit State Method; Behavior of RC members under flexure; Working stress design for common flexural members; Limit state design of beams and slabs (one-way and two way) for flexure; Singly and doubly reinforced sections; rectangular and flanged sections; S hear and torsion; Bond and anchorage; Short columns under axial compression, Short columns under axial compression with uni-axial bending, Short columns under axial compression with bi-axial bending. Slender columns Types of footings; design of isolated / combined footing

Lecture-wise break-up:

1	Introduction	3	Reinforced concrete (RC) structures, Loadings, analytical models for analysis and design of RC structures, Design Methodologies: Working Stress Method and Limit State Method
2	Flexural members: Beams	2	Behavior of RC members under flexure
		2	Working stress design for common flexural members
		7	Limit state design of beams and slabs (one-way and two way) for flexure; Singly and doubly reinforced sections; rectangular and flanged sections;
		2	S hear and torsion
		2	Bond and anchorage
3	Compression members	5	Short columns under axial compression, Short columns under axial compression with uni-axial bending, Short columns under axial compression with bi-axial bending.
		2	Slender columns
4	Footings	3	Types of footings; design of isolated / combined footing
Total		28	

Suggested text and reference material:

1	TEXT	Sinha, S.N., Reinforced Concrete Design, Tata McGraw Hill
2		Pillai, S.U., and Menon, D., Reinforced Concrete Design, Tata McGraw Hill, 2009
3	REFERENCE	Nilson, A.H., and Winter, G., Design of Concrete Structures, McGraw Hill, New Delhi

4		Park, R. and Paulay, T., Reinforced Concrete Structures, John Wiley
5		Ferguson, P.M., Bren, J.E. and Jirsa, J.O., Reinforced Concrete Fundamentals, John Wiley and Sons, New York
6		McGregor, J.M., Reinforced Concrete Mechanics and Design, Prentice Hall, New York

Main differences suggested in this review:

The content of the course has been redesigned to deliver the absolute minimum that a civil engineer is expected to know. It is expected that some of the students will augment their understanding of the subject through appropriately designed elective courses.

7.12 CE 382: Introduction to Transportation Engineering

Course Structure: 3L-0T-0P-0A (4 credits)

Pre-requisites: Pass grades in CE 242, at least an exposure grade in CE 351

Objective of the course: To introduce basic concepts of transportation engineering.

Specialized Infrastructure requirement: None.

Instructional aspects: Pre-requisites for this course are CE241, CE351

Course content: Introduction, transportation engineering elements, geometric design, traffic flow fundamentals, uninterrupted traffic flow, interrupted traffic flow, pavement analysis, highway maintenance.

Lecture-wise break-up:

Topic	Suggested number of lectures
Introduction	1
Transportation engineering elements	3
Geometric design	5
Traffic flow fundamentals	2
Uninterrupted traffic flow	7
Interrupted traffic flow	7
Pavement analysis	12
Highway maintenance	5
Total number of lectures	**42**

Laboratory Sessions: None

Suggested text and reference material:

1. Chakroborty, P. and Das, A., "Principles of Transportation Engineering", Prentice Hall of India, 2003

2. Garder, N.J. and Hoel, L.A., "Traffic & Highway Engineering", 3rd Ed., Brooks/Cole, Pacific Grove, 2001

3. McShane W.R, Roess R.P., Prassas, E.S., "Traffic Engineering", 2nd Ed., Prentice Hall 1998

Main differences suggested in this review:

(1) Based on the revision, number of lecture hours are reduced. Therefore, design component in this class is removed. The removed portion is a part of a new DE being offered.

7.13 CE 441: Construction Management

Course Structure: 2-0-0-0 (6 credits)

Pre-requisites: At least exposure grades in CE 211, CE 352 and CE 372

Objective of the course: To introduce the students to principles of construction management including the issues related to scheduling, financing, safety, and contracting. This will synthesize the construction management aspect for all aspects of civil engineering.

Specialized Infrastructure requirement: None.

Instructional aspects:

a) Effort will be made to invite practicing engineers of repute to supplement the lectures through case studies.

b) The course will not have any prerequisites.

Course content: Stakeholders in construction projects – client, consultant, contractor, financial institutions, regulators, Private Public Partnership, Environmental Impact Assessment, Planning and scheduling (PERT), resource leveling; Construction process and life cycle of a project – concept, technical feasibility, planning, qualification of bidders, award of contract, procurement (of equipment, etc.), execution, maintenance, monitoring of progress; construction equipment, safety; Contract management – types of contracts, contract process, dispute management and arbitration, labour laws, Federation Internationale des Ingenieurs Counseils (International Federation of Consulting Engineers, FIDIC); Construction economics and finance, cost estimation (clients and contractor versions), depreciation

Lecture-wise break-up:

1	4	Stakeholders in construction projects – client, consultant, contractor, financial institutions, regulators, Private Public Partnership, Environmental Impact Assessment
2	4	Planning and scheduling (PERT), resource leveling
3	6	Construction process and life cycle of a project – concept, technical feasibility, planning, qualification of bidders, award of contract, procurement (of equipment, etc.), execution, maintenance,

		monitoring of progress; construction equipment, safety
4	7	Contract management – types of contracts, contract process, dispute management and arbitration, labour laws, Federation Internationale des Ingenieurs Counseils (International Federation of Consulting Engineers, FIDIC)
5	7	Construction economics and finance, cost estimation (clients and contractor versions), depreciation
Total	28	

Suggested text and reference material:

KN Jha, Construction Project Management – Theory and Practice, Pearson

KK Chitkara, Construction Project Management – Planning, Scheduling and Controlling, (Tata Mcgraw Hill)

Main differences suggested in this review:

(1) This is a new course introduced in the present revision of the UG curriculum to expose the students to principles of construction management. It is hoped that the course will better equip them to handle their responsibilities as a civil engineer.

(2) A part of an existing (compulsory) course relating to project scheduling has been retained in this compulsory course, and that course will be redesigned as an elective.

7.14 CE 412: Water Supply and Wastewater Disposal Systems

Course Structure: 3L-0T-2P-0A (11 credits)
Pre-requisites: Pass grades in CE 211

Objective of the course: The course is designed to give the students a broad understanding of all issues related to the analysis and design of water supply and wastewater disposal systems.

Specialized Infrastructure requirement: Since the expected student strength in this course is ~60, lectures of this course may be scheduled in relatively smaller rooms, i.e., L10 or similar

Instructional Aspects: The pre-requisite for this course is CE211. This is an elective course with 3-lectures and 2 hours of design lab per week. Design lab will consist of solving design problems in the class similar to ESC 101 programming or TA 101 drawing lab.

Course Content: Introduction and Scope; Analysis and Design of Water Treatment Systems; Analysis and Design of Water Distribution Networks; Analysis and Design

of wastewater Collection Systems; Analysis and Design of Wastewater Treatment Systems; Rural Water Supply and Sanitation;

Lecture-wise break-up:

S.No.	TOPIC	Description	LECTURES
1.	Introduction	Need for water and wastewater treatment, associated environmental laws, drinking water and wastewater discharge standards, water reuse and recycling concepts	2
2.	Water Treatment	Water sources, Water quantity, process description of conventional water treatment; design of individual unit processes, water treatment plant layout and related issues.	12
3.	Water Distribution	Treated water storage structures; Design of water distribution systems	2
4.	Wastewater Collection	Description and design of wastewater collection system	3
5.	Wastewater Treatment	Quantity and quality of wastewater, process description for conventional wastewater treatment; design of individual unit processes, wastewater treatment plant layout and related issues	19
6.	Rural water supply and sanitation	Water sources, treatment and distribution systems; Rural sanitation, surface drains, septic tank, onsite sanitation systems etc.	2
		TOTAL	**40**

Suggested Text and Reference Material:

Reference Books:

Environmental Engineering. Authors: H. Peavy, D. Row and G. Tchobanoglous. Publisher: Tata McGraw-Hill.

Water Supply and Pollution Control. Authors: Warren Viessman Jr. and Mark J. Hammer. 7th Edition 2005. Publisher: Pearson Education (Indian Edition Available).

Wastewater Engineering; Treatment, Disposal, Reuse. Editors: Metcalf & Eddy. 3rd Edition (1995). Publisher: Tata McGraw-Hill (Indian Edition Available).

Additional class notes and reference material will be provided during lectures, either in softcopy or hardcopy forms.

Main differences suggested in this review:

The course is largely unchanged from its previous form. However, while earlier this was the second compulsory course on Environmental Engineering in the B. Tech. Civil Engineering syllabus at IIT Kanpur, henceforth it will be an elective course.

7.15 CE 451: Application of Geotechnical Engineering

Course Structure: 3L-0T-0P-2A (11 credits)
Pre-requisites: Pass grades in CE 351, CE 352

Objective of the course: The course prepares the student to be able to make effective learning of application of soil mechanic and foundation engineering in the area of Geotechnical Engineering.

Instructional Aspects: The pre-requisites for this course are CE351 and 352. This is an elective course with 3-lectures. The course will involve design projects equivalent to 2 hours of work per week.

Course content: Earth and Earth Retaining Structures: Slope stability analysis, flexible and rigid retaining wall, gravity, cantilever, counter fort, reinforced earth, etc., design and check for stability. Introduction to Ground Improvement Techniques: methods for difficult or problematic ground conditions soft soils, loose sands, expansive or collapsible soils, etc., preloading, vertical drains, stone columns, heavy tamping, grouting, etc, Machine foundation and design

Lecture-wise break-up:

Topic	Suggested number of lectures
Earth and Earth Retaining Structures: Slope stability analysis	10
flexible and rigid retaining wall, gravity, cantilever, counter fort	10
Reinforced earth, design and check for stability	10
Introduction to Ground Improvement Techniques: methods for difficult or problematic ground conditions soft soils, loose sands, expansive or collapsible soils, etc., preloading, vertical drains, stone columns, heavy tamping, grouting, etc, Machine foundation and design	09
Total number of lectures	**39**

Suggested text and reference material:

(i) Das BM., Principles of Geotechnical Engineering., 2007, Thomson, India.

(ii) Das BM., Advanced Soil Mechanics., 2008, Taylor and Francis, New York, USA.

(iii) Bowles JE., Foundation Analysis and Design., 1997, The McGraw-Hill Companies, Singapore.

Main differences suggested in this review:

(1) Students are introduced to applications of soil mechanics (viz earth retaining structures, slope stability analysis, etc.) to design various Geotechnical Structures.

7.16 CE 462: Hydraulic and Hydrologic Design

Course Structure: 3L-1T-0P-0A (11 credits)
Pre-requisites: Pass grades in CE 262 and CE 361

Objective of the course: This course is designed as an elective course for an undergraduate student in civil engineering at IIT Kanpur to introduce him/her the advanced topics in the design of water systems. The course consists of the hydrologic and hydraulic design including the use of computer software. At the end of the course, a successful student will have a comprehensive understanding of the various aspects of design of water systems routinely encountered in real life.

Specialized Infrastructure requirement: Related computer software (ESRI ArcGIS, Matlab, and Bentley's Haestad Methods). Some of the tutorials will be conducted in a computer lab.

Instructional aspects: None

Course Contents: Synthetic design storms & Estimation of peak discharge, Urban storm drainage design, Culvert design, Detention storage design, Watershed modeling, Flood frequency analysis and hydrologic design under uncertainty; Design of water distribution network, Analysis and design of rigid boundary channels, Tractive force concepts in channel design, Design of canal headworks, distribution works, and cross-drainage works, Design of gravity dams, spillways, and energy dissipators.

Lecture-wise break-up:

S. No.	Topic	Suggested No. of Lectures
1	Synthetic design storms & Estimation of peak discharge	03
2	Urban storm drainage design, Culvert design, & Detention storage design	08
3	Watershed modeling	03
4	Flood frequency analysis and hydrologic design under uncertainty	02
5	Design of water distribution network	03
6	Analysis and design of rigid boundary channels	04
7	Tractive force concepts in channel design	02
8	Design of canal headworks, distribution works, and cross-drainage works	08
9	Design of gravity dams, spillways, and energy dissipators	06
	Total Lectures	**39**

Suggested text and reference material:

1. Hydrologic Analysis and Design by Richard H. McCuen, Prentice Hall, New Jersey, USA.

2. Applied Hydrology by V. T. Chow, David Maidment, and Larry Mays, Tata McGraw Hill, New Delhi, India.

3. Hydraulic Design Handbook by Larry W. Mays, McGraw Hill.

Main differences suggested in this review:

This is a new course.

7.17 CE 471: Special topics in structural design

Course Structure: 3-0-0-2 (11 credits)

Pre-requisites: Pass grades in CE 272, CE 371, CE 372

Objective of the course: to expose the students to special topics in structural design including concepts of prestressed concrete design, masonry design and seismic design, and case studies in design of RC and steel structures

Specialized Infrastructure requirement: None

Instructional aspects:

a) the course is presently designed as a modular course with five modules of about 12-14 lectures each. Depending upon availability of faculty, etc. three of these modules will be covered at a given time. At the time of registration, the modules available for that semester shall be made known to the students.

b) Course in design of steel structures is a **prerequisite** for this course.

c) Course in design of reinforced concrete structures is a **prerequisite** for this course.

Course content: Elements of Prestressed concrete; Introduction to seismic design; Introduction to design of masonry structures; Case studies in design of RC Structures (RC water tank, Building frame, etc.), Case studies in design of steel structures Industrial buildings, towers, chimneys, Plate girder, chimneys)

Lecture-wise break-up:

Module	Topic	Lectures	Keywords
1	Elements of Prestressed concrete	12-14	Prestressed Concrete, Prestressing Systems, Pretensioned System, Post-tensioned System, Prestressing Tendons, Prestress Loss, Bonded Tendons, Unbonded Tendons, Internally Prestressed, Externally Prestressed, Transfer of Prestress, End Anchorages
2	Introduction to seismic	12–14	Causes of earthquakes and seismic waves, magnitude, intensity and energy release, Seismic hazards and risk;

	design		Earthquake response of structures, Design response spectrum and earthquake loads, Review of damage in past earthquakes; Philosophy of earthquake resistant design, Codal approaches to seismic analysis, design and detailing
3	Introduction to design of masonry structures	12–14	Masonry units, Mortar, Grout and reinforcement Bonding patterns, Prism strength, Masonry under compression and lateral in-plane and out-of-plane loads, Combined bending and axial loads, Shear walls and infills, Reinforcement for ductile walls, Code design provisions.
4	Case studies in design of RC Structures	12-14	RC water tank Building frame, etc.
5	Case studies in design of steel structures	12-14	Industrial buildings, towers, chimneys, Plate girder

Suggested text and reference material:

1	Pillai, S.U., and Menon, D., Reinforced Concrete Design, Tata McGraw Hill, 2009
2	Sinha, S.N., Reinforced Concrete Design, Tata McGraw Hill.
3	Subramanian, N. (2008). Design of Steel Structures, Oxford University Press.
4	Bhavikatti, S. S. (2010). Design of Steel Structures (by Limit State Method as Per IS: 800—2007), IK International
5	Krishna Raju, N. (1995). Prestressed Concrete, Tata McGraw Hill
6	Dayaratnam, P., "Brick and Reinforced Brick Structures", Oxford & IBH Publishing House, 1997

Main differences suggested in this review:

This is a new elective course, which will be available to students interested in pursuing any aspect of structural engineering professionally.

7.18 CE 481: Transportation Facilities Design

Course Structure: 3L-0T-0P-2A (11 credits)

Pre-requisites: Pass grades in CE 382

Objective of the course: To introduce design concepts of transportation facilities including highways, pavement, and traffic facilities.

Specialized Infrastructure requirement: None.

Instructional aspects: Two of the three modules listed below will be offered for a total of 42 hours in a semester. Pre-requisite for this course is CE 382. In addition to the lectures, the course will have assignments and projects equivalent to 2 hours of work per week.

Course content: Any two of the three modules listed below will be taught in any given semester.

Module 1 - Traffic Design: Introduction, freeway and toll booths, intersections/ interchanges, signs and lighting, arterials/ weaving section, congestion mitigation.

Lecture-wise break-up:

Topic	Suggested number of lectures
Introduction	2
Freeways and toll booths	3
Intersections/ interchanges	10
Signs and lighting	2
Arterials/ weaving sections	2
Congestion mitigation	2
Total number of lectures	**21**

Module 2 – Pavement Design: Introduction, design parameters, bituminous pavement, concrete pavement, composite pavement.

Lecture-wise break-up:

Topic	Suggested number of lectures
Introduction	3
Design parameters	4
Bituminous pavement	6
Concrete pavement	6
Composite pavement	2
Total number of lectures	**21**

Module 3 – Geometric Design: Introduction, design controls and criteria, freeway design, arterial/collector design, at-grade intersections, terminals.

Lecture-wise break-up:

Topic	Suggested number of lectures
Introduction	2
Design controls and criteria	2
Freeways	6
Arterials/collectors	4
Intersections/ interchanges	5
Terminals	2
Total number of lectures	**21**

Laboratory Sessions: None

Suggested text and reference material:

Chakroborty, P. and Das, A., "Principles of Transportation Engineering", Prentice Hall of India, 2003

Garder, N.J. and Hoel, L.A., "Traffic & Highway Engineering", 3rd Ed., Brooks/Cole, Pacific Grove, 2001

McShane W.R, Roess R.P., Prassas, E.S., "Traffic Engineering", 2nd Ed., Prentice Hall 1998

American Association of State Highway and Transportation Officials (AASHTO), "A Policy on Geometric Design of Highways and Streets", 5th Ed., AASHTO, 2004

Main differences suggested in this review:

None. It is a new course.

7.19 CE 422: Physical and Environmental Geology

Course Structure: 3L-0T-0P-0A (9 credits)
Pre-requisite: Pass grades in CE 321 or CE 322

Objective of the course: The course teaches the student both basic and advanced concepts in physical Earth surface processes and environmental geology.

Specialized Infrastructure requirement: None.

Instructional aspects: This course is a departmental elective as well as a part of the 'Minor' in Earth Science proposed by CE department. For non-CE students the course CE 322 is a pre-requisite.

Course content: Earth as a system; Fundamental concepts in environmental geology, population dynamics and its impact; Geological cycles - rock and hydrological cycle; Soil and environment (profile, classification, soil types of India, soil pollution and remediation); Natural Hazards (flooding, landslides, volcanism, coastal, earthquake) and environmental degradation; Surface and ground water system & management; Surface and groundwater system and management, Water pollution and remediation, Waste management (solid, liquid and radioactive waste); Atmospheric processes and related hazards - cyclones and hurricanes; Geochemical cycles – carbon, nitrogen and phosphorous; Life on Earth - ecosystem and biodiversity; Earth's Energy balance, green house effect, and global warming; Human role in environmental changes.

Lecture-wise break-up:

Topic	Suggested number of lectures
Earth as a system	2
Fundamental concepts in environmental geology	3

Geological cycles	2
Soil and environment	3
Natural hazards and environmental degradation	6
Surface and ground water system & management	7
Water pollution and treatment	3
Waste management	2
Atmospheric processes and related hazards	2
Geochemical cycles- C, N, & P	2
Life on Earth- Ecosystem & biodiversity	2
Earth's energy balance, green house effect, and global warming	4
Human role in environmental changes	2
Total number of lectures	**40**

Laboratory Sessions: None

Suggested text and reference material:

1. Keller, Edward (2005). Introduction to Environmental geology, Prentice Hall.
2. Merrits, D., Dewet, A. and Menking, K., (1998) Environmental geology; an earth system science approach, Freeman
3. Skinner, B.J. and Porter, S.C. (2000) The Dynamic Earth, John Wiley
4. Wicadner, R. & Monore, J.S. (1999) Essentials of Geology, Wadsworth Pub. Co.

Main differences suggested in this review:

1. Few new topics of significance in environmental geology (atmospheric processes, geochemical cycles, ecosystem and biodiversity) have been included in this version.
2. Role of humans in earth-environment interactions has been emphasized which increases the societal relevance of the course.

7.20 CE 432: Advanced Land Measurement Techniques

Course Structure: 3L-0T-0P-0A (09 credits)
Pre-requisites: Pass grades in CE 331

Objective of the course: The course is aimed at those who have already done CE371: Geoinformatics. This course exposes students to some of the advanced methods of land measurement. The course will prepare students to design and execute larger projects where mapping is an essential component using much advanced technologies. Further, it will help them see the research frontiers in land measurement.

Specialized Infrastructure requirement: This course will be having only laboratory classes. However, home assignments will include lot of work on different software. These software, e.g. for photogrammetry, for laser scanning data processing, and GPS data processing etc. will be required along with peripheral GIS and CAD software.

Instructional aspects: A good number of home assignments will given to students. Use of modern teaching methods LCD, Tablet etc. will enhance value.

Course content: GPS-range and time measurements, errors, surveying methodologies and field procedures; Laser Scanning-physics of laser, laser interaction, different methods of range measurements with advantages and disadvantages, laser scanning types, components of LiDAR systems, INS-GPS integration, errors in laser scanning, laser scanning applications; Photogrammetry-camera types, geometry of photographs, distortions and rectifications, stereoscopy, parallax and use, interior and exterior orientation, mathematical model relating image and object space, bundle block adjustment.

Lecture-wise break-up:

Topic	Suggested number of lectures
GPS basic concepts: pseudo range and carrier phase measurements; GPS coordinate systems- WGS-84, GPS time	4
GPS Errors: Errors and biases in GPS- timing, orbital, ionospheric and tropospheric effects; Ambiguity resolution; Cycle slips, Multipath and other observational errors	5
GPS Surveying procedures: Surveying with GPS- point positioning, relative positioning, static and kinematic positioning, Planning and field observations- networking	5
Laser physics: spectral characteristics of laser, laser interaction with objects	2
Measurement of laser range-CW and pulse method, laser pulse, energy, pulse width and related definitions; LiDAR equation and related physics	5
Principle of laser scanning: Basic concept of scanning and computation; Sensor specifications, point repetition frequency, scanning frequency, maximum and minimum range, INS, GPS, and INS-GPS integration; different types of scanning sensors Topographic and bathymetric laser scanning; Footprint, Multiple return, full wave digitization for data capture;	5
Laser applications: DEM generation algorithms and introduction to other applications	3
Photogrammetry: Metric and non-metric cameras; Geometry of near vertical and tilted photographs, heights and tilt distortions; Rectification and orthophotographs	3
Stereoscopy, parallax equation and stereo measurements for height determination	3
Orientation- interior, exterior, relative, and absolute; Mathematical model relating image, model and object space; Collinearity and coplanarity conditions, Bundle block triangulation	5

Total number of lectures	40

Laboratory Sessions: No laboratory in this course.

Suggested text and reference material:

GPS Satellite Surveying, Alfred Leick, John Wiley

GPS for Land Surveyors, Sickle, J. V. Ann Arbor Press

David F. Maune(2002): Digital elevation model technologies and applications: The DEM users manual:; Manual of Remote Sensing: ASPRS; 2002

George Vosselman and Hans-Gerd Maas(2010), Airborne and Terrestrial laser scanning, CRC Press, New York

Jie Shan and Charles K Toth (2009) Topographic laser ranging and scanning: principle and processing, CRC Press, New York

Moffit, Francis H. and Mikhail, Edward M. Photogrammetry. Third Ed., New York:Harper & Row, 1980.

Wolf, Paul, R. Elements of Photogrammetry. Second Ed., McGraw-Hill, 1982.

Main differences suggested in this review: This is a new course.

7.21 CE 642A: Civil Engineering Systems Analysis

Course Structure: 3L-0T-0P-0A (09 credits)
Pre-requisites: Pass grades in MTH 101, MTH 102 and SO-3 or instructors consent

Objective of the course: The course prepares a student to use different systems analysis tools to understand and structure various civil engineering systems.

Specialized Infrastructure requirement: None

Instructional aspects: None.

Course content: Introduction to the course and its importance; optimization methods: introduction, problem formulation, solution techniques for linear and integer problems, sensitive analysis; multi-objective optimization; introduction to non-linear problems, case studies from civil engineering. Introduction to non-traditional optimization methods. Decision making in uncertain environment.

Lecture-wise break-up:

Topic	Suggested number of lectures
Introduction to course	1
Unconstrained optimization	3
Constrained optimization (including LP and IP)	10

Sensitivity analysis	4
Introduction to non-linear problems	4
Multi-objective optimization	4
CE case studies	6
Introduction to non-traditional optimization methods	3
Decision making in uncertain environment	5
Total number of lectures	**40**

Suggested text and reference material:

Hamdy A. Taha. Operations Research: An Introduction. McMillan

Richard de Neufville. Applied Systems Analysis. McGraw Hill

Main differences suggested in this review:

(1) Statistics removed.

(2) Sensitivity analysis introduced in some detail.

(3) Multi-objective optimization included.

7.22 CE 491: UG Research I

Course Structure: 0L-0T-0P-9A (9 credits)
Pre-requisites: Consent of the Adviser

Objective of the course: The course introduces the student to the world of research. The students will be expected to carry out original work independently in an area chosen by the students under the guidance of a faculty member mutually agreed between the student and the concerned faculty member.

Specialized Infrastructure requirement: None

Instructional aspects: The course may consist of reading, laboratory work, modeling, theoretical development etc. depending on the problem of research. Total hours to be spent for this course is expected to be 9 per week.

Course content: Variable according to the research problem chosen.

Lecture-wise break-up: No scheduled lectures.

Laboratory Sessions: No scheduled laboratory session. However, the student may need to work in the laboratory if the research problem demands so.

Suggested text and reference material: Depends on the problem

Main differences suggested in this review:

Earlier, a B. Tech Project was compulsory. In this review, it has been made optional (an elective in Basket B). Only the students interested in research as a career option are expected to take this course.

7.23 CE 492: UG Research II

Course Structure: 0L-0T-0P-9A (9 credits)
Pre-requisites: Pass grades in CE 491 and consent of the adviser.

Objective of the course: This would be the 2nd research course for the student. The students will be expected to have already gained exposure in the research.

Specialized Infrastructure requirement: None

Instructional aspects: The course may consist of reading, laboratory work, modeling, theoretical development etc. depending on the problem of research. Total expected hours to be spent for this course is expected to be 9 per week.

Course content: Variable according to the research problem chosen.

Lecture-wise break-up: No scheduled lectures.

Laboratory Sessions: No scheduled laboratory session. However, the student may need to work in the laboratory if the research problem demands so.

Suggested text and reference material: Depends on the problem

Main differences suggested in this review:

Earlier, a B. Tech Project was compulsory. In this review, it has been made optional (an elective in Basket B). Only the students interested in research as a career option are expected to take this course.

7.24 CE 332: Survey and Geology Camp

Course Structure: 0L-0T-4P-0A (4 credits)
Pre-requisites: Pass in CE 331 and CE 321. Maximum class strength is 50.

Objective of the course: The objective of the course is:

1) To train students in planning and carrying out field surveys for topographical mapping related to Civil Engineering.

2) To prepare the students to be able to understand geological concepts by undertaking extensive field survey and mapping of geological structures.

Objective of the course: This would be a research course for the exceptional students over and above their normal load.

Specialized Infrastructure requirement: None

Instructional aspects: The course may consist of reading, laboratory work, modeling, theoretical development etc. depending on the problem of research. Total expected hours to be spent for this course is expected to be 9 per week.

Course content: Variable according to the research problem chosen.

Lecture-wise break-up: No scheduled lectures.

Laboratory Sessions: No scheduled laboratory session. However, the student may need to work in the laboratory if the research problem demands so.

Suggested text and reference material: Depends on the problem

Main differences suggested in this review: New Course

7.26 CE 322: Earth Science
Course Structure: 3L-0T-0P-0A (9 credits)
Pre-requisites: None

Objective of the course: The course provides the basic undertanding of how the earth's processes operate and how the different components of the earth interact to make this planet habitable.

Specialized Infrastructure requirement: None

Instructional aspects: This course is a part of the Minor in 'Earth Sciences' and will be offered as an open elective to students outside the CE department.

Course content:

Earth as a system – Lithosphere, atmosphrere, hydrosphere, bioshopere and their interactions; Theory of plate tectonics; Geological Time scale and stratigraphy; The Solid Earth - Magmatism and volcanism; Sedimentary processes, Metamorphism and metamorphic rocks; rock-forming minerals; Crustal deformation and mountain building. Weathering, erosion and mass movement processes; Earth's landscape – processes and products, the work of rivers, oceans and glaciers; Groundwater hydrology and exploration; Atmospheric system – composition, structure and circulation; Hazardous Earth processes - Floods, Earthquakes, Landslides. Introduction to environmental Geology; Earth's climate system and global change.

Lecture-wise break-up:

Topic	Suggested

	number of lectures
Earth as a system	2
Theory of plate tectonics	4
Geological time scale and stratigraphy	2
The Solid earth – rocks and minerals	6
Crustal deformation and mountain building	5
Weathering, erosion and mass movement processes	5
Earth's landscape – processes and products	5
Groundwater hydrology and exploration	2
Atmospheric system – composition, structure and circulation	2
Hazardous Earth processes	2
Introduction to environmental Geology	2
Earth's climate system and global change	3
Total number of lectures	**40**

Suggested text and reference material:

1. Grotzinger. J., Jordan, T.H., Press, F., Siever, R. (2007). Understanding Earth. Freeman.

2. Skinner, B.J. and Porter, S.C. (2000) The Dynamic Earth, John Wiley

3. Wicadner, R. & Monore, J.S. (1999) Essentials of Geology, Wadsworth Pub. Co.

4. Merrits, D., Dewet,A. and Menking, K., (1998) Environmental geology; an earth system science approach, Freeman

5. Ernst, W.G. (2000) Earth Systems – processes and issues. Cambrudge University Press.

Main differences suggested in this review:

(1) A tutorial hour is strongly recommended for deminstrations and using the modern audio-visual aides for teaching.

(2) Several modern topics relating to earth-human interactions have been included. A system concept is emphasized and interactions among different components to be highlighted.

(3) It is recommended that the students need to have a better awareness of the Planet Earth and therefore a process-based understanding is emphasized in this review.