DESIGN OF CONCRETE STRUCTURES -1

Topics to be covered:

- Introduction to Various Design Philosophies
- Working Stress Method
- Ultimate Load Method
- Limit State Method

PREPARED BY:

SHASHIKANT SRIVASTAVA

ASSISTANT PROFESSOR

DEPARTMENT OF CIVIL ENGINEERING

FACULTY OF ENGINEERING & TECHNOLOGY

RAMA UNIVERSITY UTTAR PRADESH, KANPUR (INDIA)

INTRODUCTION TO VARIOUS DESIGN PHILOSOPHIES :

Concrete design methods or concrete design philosophies such as working stress method, ultimate strength method, and limit state method are used for the design of reinforced concrete, Steel, and timber structures.

These design methods are based on certain assumptions and procedures which are used to meet the conditions of safety, functionality, serviceability, and economy of the structure.

Several design philosophies have been introduced from different parts of the world. These design philosophies are commonly accepted by various codes, for instance, the ultimate strength method is established in the 1950s and accepted by ACI code in 1956, British codes in 1957, and Indian codes in 1964. Similarly, the limit state method is the most recent one which is accepted by the ACI Code, British Code, and Indian Standard.

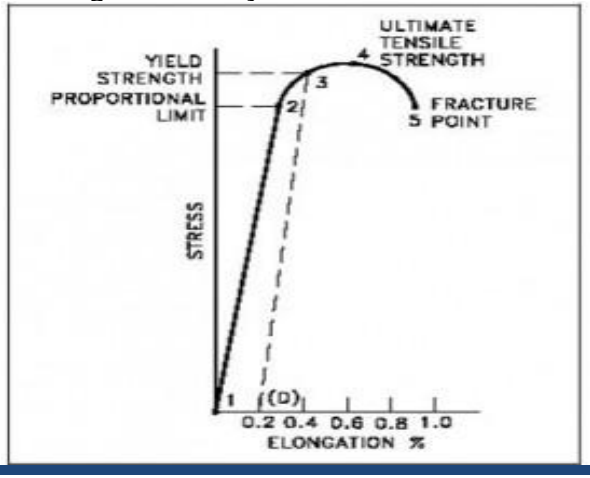
A design philosophy is a set of assumptions and procedures which are used to meet the conditions of serviceability, safety, economy and functionality of the structure. Several design philosophies have been introduced from different parts of the world. Some of the design philosophies that has been used by engineers are :

a) Working Stress Method(WSM)/ Allowable Stress Design (ASD)
b) Ultimate Load Method (ULM)
c) Limit State Method(LSM)

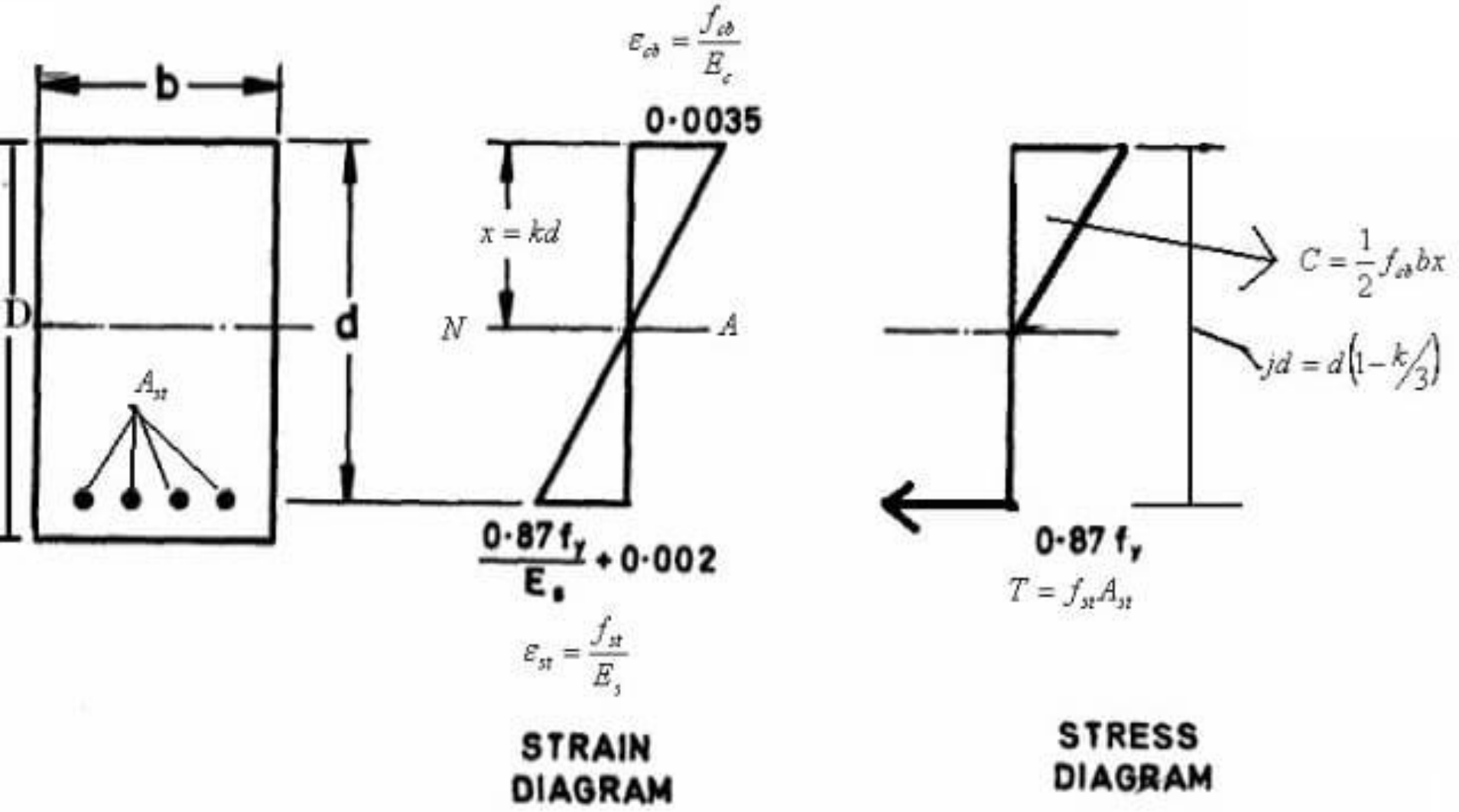
The earliest one is working stress method, which was introduced in 20th century. This is based on linear elastic theory. This method was used in IS 456 till revision IS 456:2000. In 1950s Ultimate Load method was introduced which is based on the ultimate load which can be carried out by material. Its acceptance can be seen in ACI code in 1956 and British codes in 1957 and Indian codes in 1964. The most recently accepted code of practice is based on Limit State method. This is used in IS 456 from revision IS 456:2000, British code CP 110(1973) (now BS 8110(1997)) and ACI 318-71 (now ACI 318-95).

WORKING STRESS METHOD/ ALLOWABLE STRESS DESIGN :

- Working stress method is used for the design of Reinforced concrete, Steel and Timber structures.
- The main assumption in the WSM is that the behaviour of structural material is restricted with in linear-elastic region and the safety of it is ensured by restricting the stresses coming on the members by working loads.
- Thus the allowable stresses will come in the linear portion (i.e., initial phase) of the stress-strain curve.
- Thus a factor of safety was introduced to the design *"Factor of safety is the ratio of strength of material to the permissible stress".*
- When we consider the effect of creep, shrinkage, stress concentrations and others secondary effects the assumption of material behaviour in the elastic range will not hold.
- These will lead to increase of stresses into the inelastic range.
- WSM cannot account for loads acting simultaneously, but has different degrees of uncertainty.
- It cannot account for the loads having counteracting effects, such as dead load and wind load.
- The above will lead to non-conservative design.
- Working Stress method will lead to large FOS and over-sized sections, thus reducing the design economy.
- WSM is still being using in special structures such as water tanks, chimneys in India.
- Elastic regions holds good in serviceability checks such as crack width, deflection etc.



WORKING STRESS METHOD/ ALLOWABLE STRESS DESIGN :

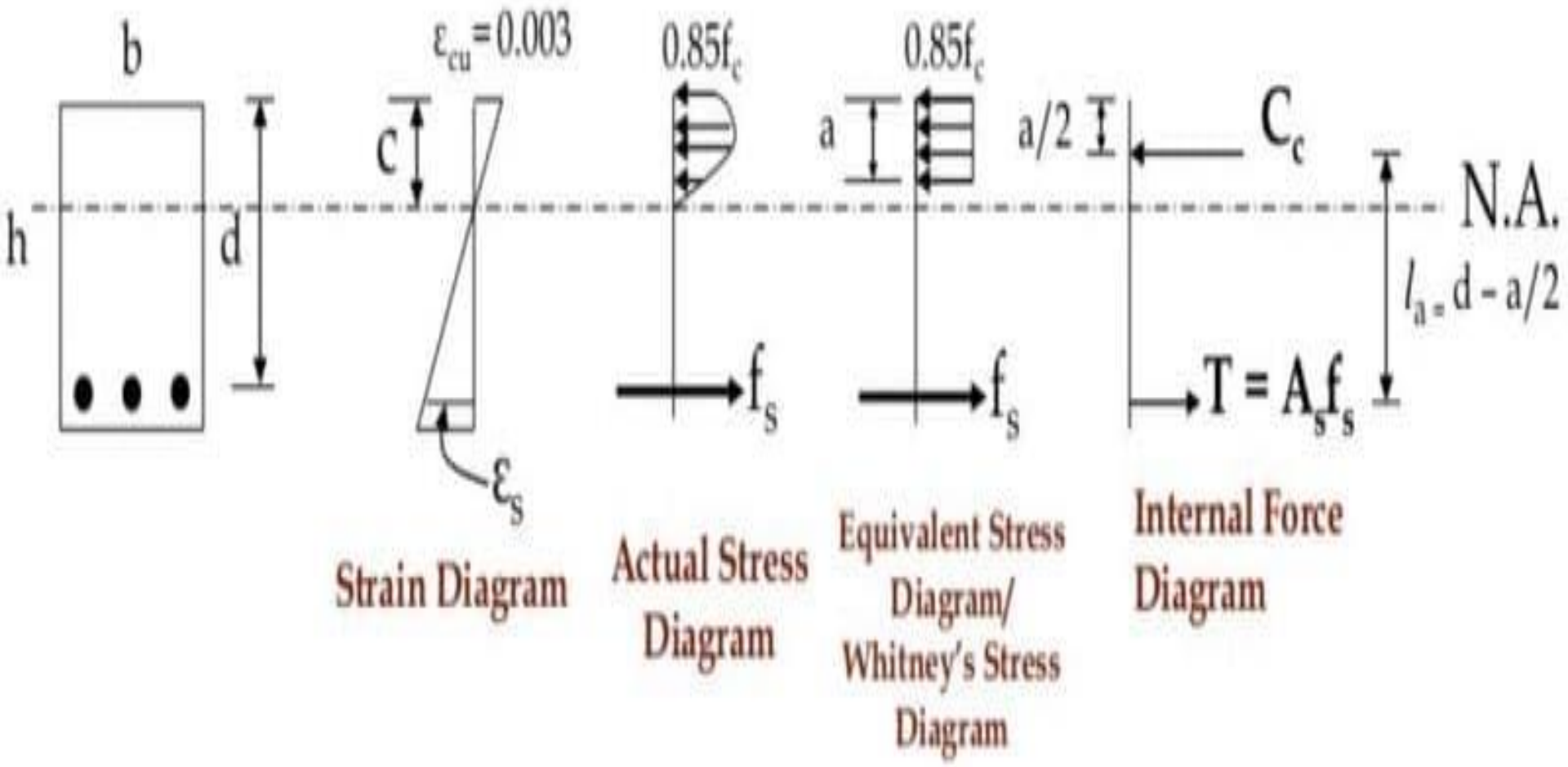


STRESS AND STRAIN DIAGRAM BASED ON WORKING STRESS METHOD

ULTIMATE LOAD METHOD :

- This is also known as load factor method or ultimate strength method.
- In this we make use of the nonlinear region of stress strain curves of steel and concrete.
- The safety is ensured by introducing load factor.
- *"Load factor is the ratio of ultimate strength to the* service loads"
- The ULM makes it possible to consider the effects of different loads acting simultaneously thus solving the shortcomings of WSM.
- As the ultimate strength of the material is considered we will get much slender sections for columns and beams compared to WSM method.
- But the serviceability criteria is not met because of large deflections and cracks in the sections.
- The fall-back in the method was that even though the nonlinear stress strain behaviour of was considered sections but the nonlinear analysis of the structural was not carried out for the load effects.
- Thus the stress distribution at ultimate load was just the magnification of service load by load factor following the linear elastic theory.

ULTIMATE LOAD METHOD :

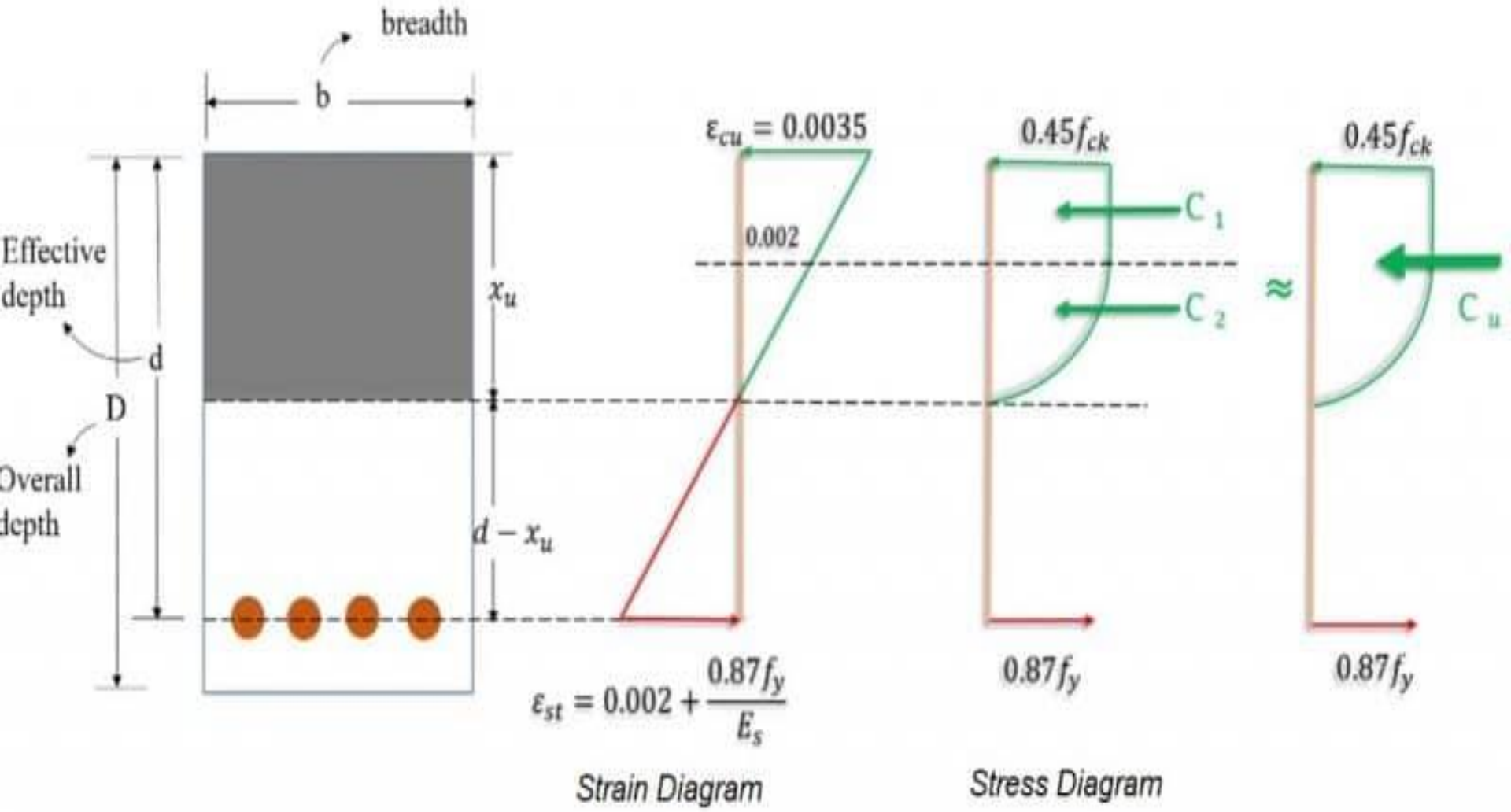


STRESS AND STRAIN DIAGRAM BASED ON ULTIMATE STRENGTH METHOD

LIMIT STATE METHOD :

- This philosophy is an advancement over the traditional design philosophies.
- It considers the safety at the ultimate load and serviceability at the working load, sort of extension of the WSM and ULM.
- *"Limit state is the state of impending failure, beyond which a structure ceases to perform its intended function satisfactorily, in terms of either safety or serviceability."*
- There are 2 types of limit states as :
    (a) Ultimate Limit State: It considers strength, overturning, fatigue, sliding etc.
    (b) Serviceability Limit State: It considers crack width, deflection, vibration etc.
- Limit state design (LSD), also known as load and resistance factor design (LRFD), refers to a design method used in structural engineering.
- A limit state is a condition of a structure beyond which it no longer fulfils the relevant design criteria.
- The condition may refer to a degree of loading or other actions on the structure, while the criteria refer to structural integrity, fitness for use, durability or other design requirements.
- A structure designed by LSD is proportioned to sustain all actions likely to occur during its design life, and to remain fit for use, with an appropriate level of reliability for each limit state.
- Building codes based on LSD implicitly define the appropriate levels of reliability by their prescriptions.
- The method of limit state design, developed in the USSR and based on research led by Professor N.S. Streletski, was introduced in USSR building regulations in 1955.

LIMIT STATE METHOD :



STRESS AND STRAIN DIAGRAM BASED ON LIMIT STATE METHOD

“Thank you”

Have Any Query ?

Ask us @ shashikant.fet@ramauniversity.ac.in or shashikantchitransh3@gmail.com