- **ENDURANCE LIMIT**

- The fatigue or endurance limit of a material is defi ned as the maximum amplitude of completely reversed stress that the standard specimen can sustain for an unlimited number of cycles without fatigue failure.
- Since the fatigue test cannot be conducted for unlimited or infi nite number of cycles, 106 cycles is considered as a suffi cient number of cycles to defi ne the endurance limit.
- There is another term called fatigue life, which is frequently used with endurance limit.
- ***The fatigue life is defi ned as the number of stress cycles that the standard specimen can complete during the test before the appearance of the fi rst fatigue crack.***
- The dimensions of the standard test specimen (in mm) are shown in Fig. 5.17

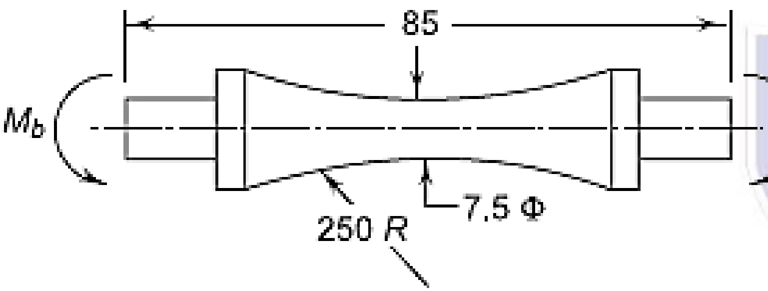

Fig. 5.17 *Specimen for Fatigue Test*

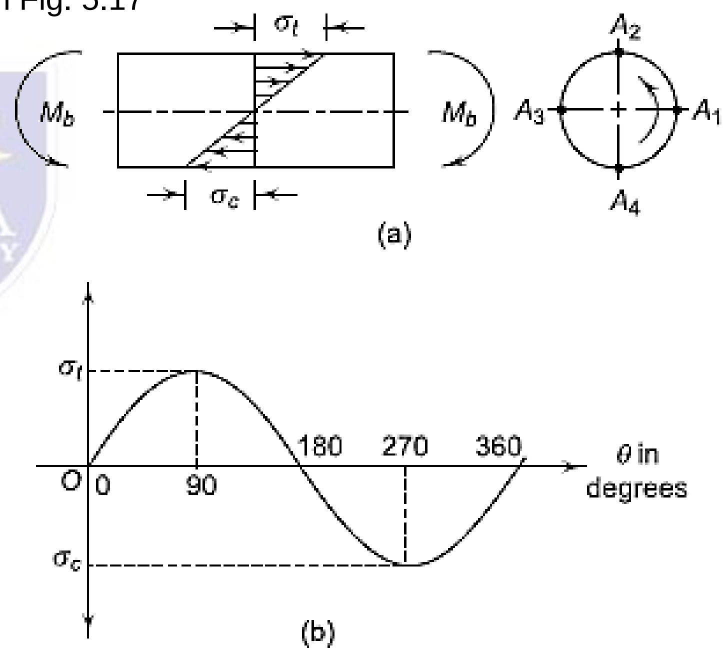

Fig. 5.18 *Rotating Beam Subjected to Bending Moment: (a) Beam, (b) Stress Cycle at Point A*

- **S-N Curve :**
- A schematic diagram of a rotating beam fatigue testing machine is shown in Fig. 5.19. The specimen acts as a 'rotating beam' subjected to a bending moment. Therefore, it is subjected to a completely reversed stress cycle.
- Changing the bending moment by addition or deletion of weights can vary the stress amplitude. The specimen is rotated by an electric motor.
- The number of revolutions before the appearance of the fi rst fatigue crack is recorded on a revolution counter.
- In each test, two readings are taken, viz., stress amplitude (Sf) and number of stress cycles (N).
- These readings are used as two coordinates for plotting a point on the S–N diagram. This point is called failure point.
- To determine the endurance limit of a material, a number of tests are to be carried out.The results of these tests are plotted by means of an S–N curve.
- The S–N curve is the graphical representation of stress amplitude (Sf) versus the number of stress cycles (N) before the fatigue failure on a log-log graph paper. The S–N curve for steels is illustrated in Fig. 5.20.
- Each test on the fatigue testing machine gives one failure point on the S–N diagram. In practice, the points are scattered in the fi gure and an average curve is drawn through them.
- The S–N diagram is also called Wöhler diagram, after August Wöhler, a German engineer who published his fatigue research in 1870. T
- he S–N diagram is a standard method of presenting fatigue data.For ferrous materials like steels, the S–N curve becomes asymptotic at 106 cycles, which indicates the stress amplitude corresponding to infi nite number of stress cycles. The magnitude of this stress amplitude at 10 6 cycles represents the endurance limit of the material.
- The S–N curve shown in Fig. 5.20 is valid only for ferrous metals. For nonferrous metals like aluminium alloys, the S–N curve slopes gradually even after 106 cycles.
- These materials do not exhibit a distinct value of the endurance limit in a true sense. For these materials, endurance limit stress is sometimes expressed as a function of the number of stress cycles.

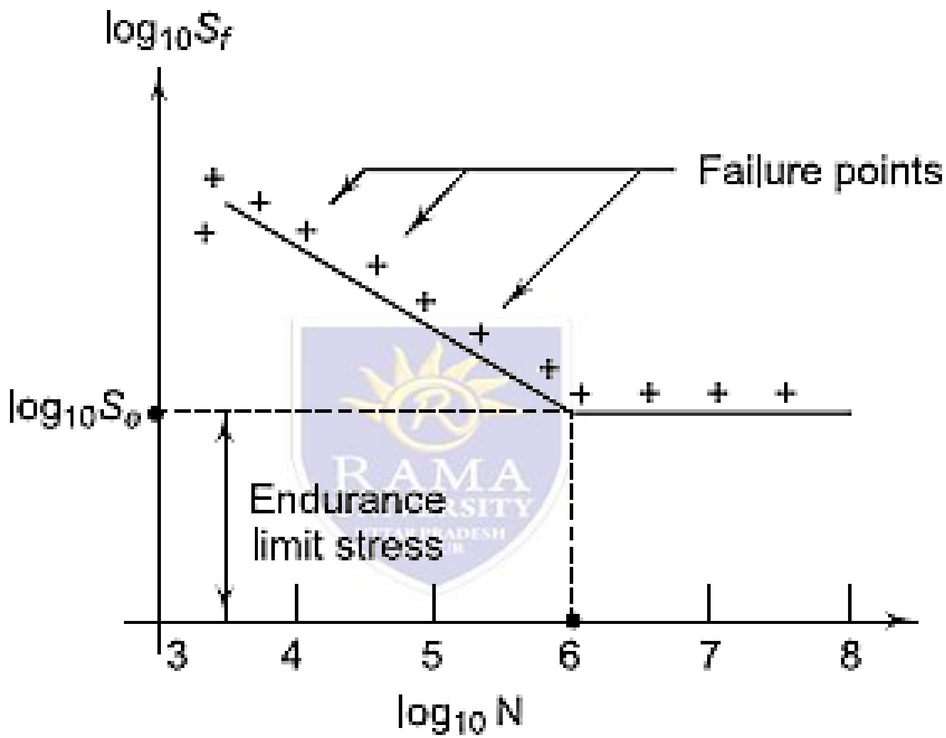

Fig. 5.20 *S-N Curve for Steels*

- LOW-CYCLE AND HIGH-CYCLE FATIGUE
- The S–N curve illustrated in Fig. 5.20 is drawn from 103 cycles on a log-log graph paper. The complete S–N curve from 100 cycle to 108 cycles is shown in Fig. 5.21. There are two regions of this curve namely, low-cycle fatigue and high-cycle fatigue. The difference between these two fatigue failures is as follows:
- (i) Any fatigue failure when the number of stress cycles are less than 1000, is called low-cycle fatigue. Any fatigue failure when the number of stress cycles are more than 1000, is called high-cycle fatigue.
- (ii) Failure of studs on truck wheels, failure of setscrews for locating gears on shafts or failures of short-lived devices such as missiles are the examples of low-cycle fatigue. The failure of machine components such as springs, ball bearings or gears that are subjected to fl uctuating stresses, are the examples of high-cycle fatigue.
- (iii) The low-cycle fatigue involves plastic yielding at localized areas of the components. There are some theories of low-cycle fatigue. However, in many applications, the designers simply ignore the fatigue effect when the number of stress cycles are less than 1000. A greater factor of safety is used to account for this effect.
- Such components are designed on the basis of ultimate tensile strength or yield strength with a suitable factor of safety. Components subjected to high-cycle fatigue are designed on the basis of endurance limit stress.
- S–N curves, Soderberg lines, Gerber lines or Goodman diagrams are used in the design of such components. The discussion in this chapter is restricted to high-cycle fatigue failure of machine elements.

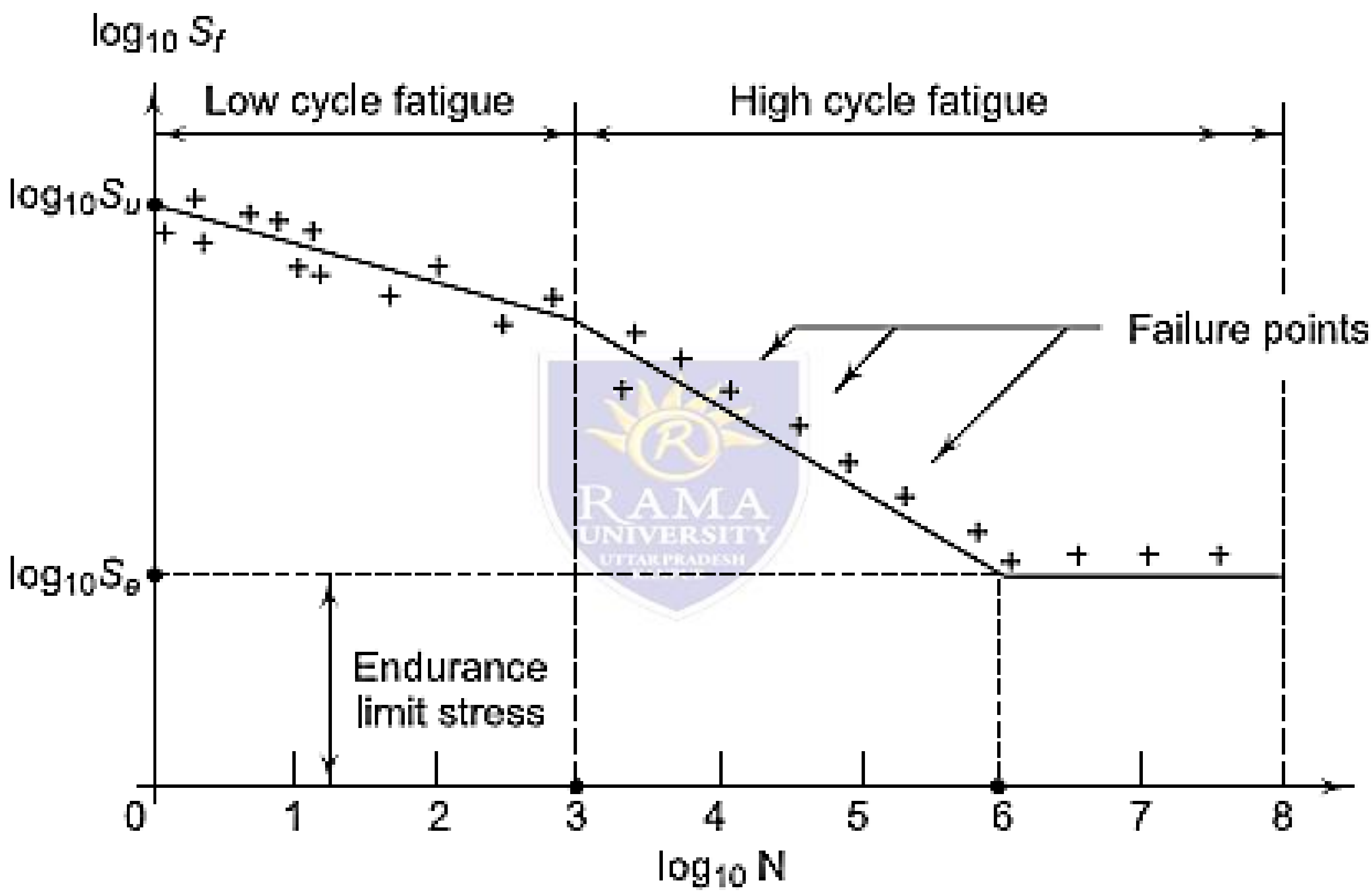

Fig. 5.21 *Low and High Cycle Fatigue*