Methodologies for Reliability-Based Design (RBD) of structural components have witnessed rapid development during the past few years. Member-level Reliability-Based design procedure may not yield a satisfactory structural system safety. This is due to the fact that multi-component behaviour has a severe impact on the true risk of structural system failure. Conversely, system-level RBD procedure may also not satisfy member-level reliability requirements. Since the safety of the structural system as a whole is of interest, a designer should be able to select a system reliability level, and then assign component reliabilities accordingly. Hence it is very essential to establish a relationship between member-level and system-level reliability as part of the formulation of RBD methodology. Structural system reliability analysis methods have developed considerably in recent years. But the practical inclusion of structural system reliability at the design level has not received much attention. The new generation of Reliability-Based Load and Resistance Factor Design (LRFD) methodology for transmission line structural systems are based on member-level reliabilities. These codes and specifications do not utilise the benefits of structural system reliability. Hence a system-level reliability-based LRFD methodology for the design of transmission line structures is needed.

Even though a transmission line is a structural system, the system-level RBD applicable to tower structure cannot be applied to design the entire line. The structural system reliability for a complete transmission line is indeed unique due to the large spatial extent of the line. It is essential to incorporate the spatial
characteristics of the loading events and the varying use factors of the towers in the line-based RBD formulation.

In this thesis, reliability-based wind load and resistance factors are established as part of the formulation of RBD methodology for the design of transmission line in India. Dynamically amplified unbalanced longitudinal load resulting from broken wire loading is a decisive factor in performing the load analysis of critical members. A procedure for nonlinear static and dynamic analysis of transmission line system under broken wire conditions is presented and dynamic amplification factor is suggested for Indian Standard.

Current Reliability-Based LRFD formats for the design of transmission line structures are examined. A component-level RBD methodology is presented for India, keeping in line with the ASCE Manuals and IEC rules. It is suggested that the limiting values of L/r ratio of leg and cross-arm bottom members as specified in the ASCE and IS codes be modified. Using this methodology, the designer is able to assign relative levels of reliabilities to different components within one tower structure. A full-scale tower test is conducted to validate the methodology at the pre-design stage.

Nonlinear force-deformation at member-level and second order geometric effects at system-level play an important role in the formulation of RBD methodology of transmission line structural system. A realistic force-deformation model is presented for tower members in compression and tension. A general purpose procedure of structural system reliability analysis of transmission tower is presented incorporating member and system level nonlinearities. A series of
parametric studies are carried out to identify the parameters that affect the design of tower structures at system level. The system reliability of tower structures depends on various parameters such as the system model, post-buckling factor, correlation between member strengths, load and strength variations. A system-level RBD procedure is demonstrated. For this a concept of using the System Reliability Factor (SRF) is introduced for the first time in the design of transmission towers. Design graphs give the relationship between SRF and Line Reliability Factor (LRF) for ideal series and parallel systems and also relate other parameters. With this proposed methodology, the designer is able to assign relative levels of reliability to different tower structures within one line. A full scale 230 kV transmission tower was tested and predicted failure sequences were compared with practically observed failure sequences.

Transmission lines are modelled as series system in which each tower structure is one component. The relationship between the probability of failure of a line and the probability of failure of a tower structure is established. The effects of use factor and wind direction on reliability are also established. A new line-level RBD methodology is proposed. Design graphs are presented for line system reliability factors. The designer is, hence able to assign relative levels of reliability to proposed lines or to assess the reliability of an existing transmission line. A case study of a typical transmission line is used to demonstrate the efficacy of the proposed methodology.