

## **1.054/1.541 Mechanics and Design of Concrete Structures (3-0-9)**

### **Outline 15**

#### **High-rise Concrete Buildings**

High-rise buildings are a distinct part of urban life around the world. Scarcity of land in the urban settings, increasing demand for business and residential space, economic growth, technological advancements, and innovations in structural systems and materials have led to an impressive evolution of these systems. Desire for aesthetics in urban design and the concept of city skyline, cultural significance and prestige, and human aspiration to build higher are also among the forces behind the demand for high-rise buildings. During the initial rapid development phase, the race to the sky was pushed from the 10 story Home Insurance Building of Chicago built in 1885 to the 102 story Empire State Building in 1931, in less than 50 years. Following a hiatus of over thirty years, developments in high-rise buildings were revived once again in 1960s, reaching new heights by leaving the shear frame systems behind and recognizing a hierarchy of new structural forms such as interacting systems, partial tubular systems, tubular systems, and hybrid systems. Recent developments in the area of high performance materials have further fueled this evolution. The tallest buildings of the 21<sup>st</sup> century are in excess of 1500 ft (457 m) high, and the dreams of mile-high building and sky cities may be hindered by issues other than technical feasibility. Increase in height of buildings leads to enhanced challenges including structural safety, control of deflections, human comfort, fire safety, exit strategies, crowd control, and security. Owing to the advances in load prediction methods and structural analysis tools, specialty design process, and quality construction practice, high-rise buildings are among the safest structures against wind and seismic loads. In addition, efficient structural systems coupled with passive and active



damping/control systems help reduce structural vibrations to prevent discomfort. However, accidental and deliberate extreme loadings such as impact and blast effects may jeopardize structural stability especially when coupled with fire. These effects bring the issues of fire safety, security and exit concerns. Among several classes of specialty structures, high-rise buildings generally allow easy public access and their symbolism of cultural and economical dominance makes them well-defined targets. Failure of a high-rise building is often of a colossal type having a profound social and economical impact. Thus, especially in the wake of the collapse of World Trade Center (WTC) towers, there will be a considerable increase in the performance demand for high-rise buildings, particularly against progressive failure mechanisms. Structural systems that maintain stability for extended periods under fire by means of redundancy, use of fire resistant materials, and introduction of efficient egress routes are essential elements of an effective emergency exit strategy. This lecture reviews evolutionary development aspects of high-rise building systems with emphasis on concrete tall buildings and the recent increase of the role of high performance concrete in developing innovative high rise building solutions. Forward-looking strategies on fire safety and egress systems will also be discussed.