theoretical solutions suggested for composite elements, should these be compared with methods and solutions applied for researching steel-concrete columns.

It is well known that restraining deformation of concrete is related to pressure exerted by lateral reinforcement, a steel tube or steel section. In the effect of confinement, compressive strength of concrete increases. That is conditional on numerous factors, which can be classified as the following:
- type of structure and type of confinement related to it (steel-concrete or composite column)
- type of composite cross section (ex. concrete-encased section or concrete filled tube)
- shape of cross section (circular, rectangular, polygonal)
- geometry of the cross section - dimensions and thickness of tube walls.

Experimental research as well as analytical calculations most often aim at assessing quantitative and qualitative influence of the above parameters on the effective concrete strength in different types of composite columns cross sections. Cheng-Chih Chen (2006) offered a comprehensive analysis of the effect the shape and layout of steel sections in a given cross section have on stress distribution in concrete and the resultant load capacity of columns. The confinement of concrete in CFST rectangular cross section columns was presented by Ge (1994) and Jian Cai (2006). Additionally, research has been carried out on CFST rectangular cross sections, with a view to deriving benefits from the complex character of stress distribution in concrete. These can be achieved through seeking solutions at the stage of construction design (Hsuan-Teh Hu 2003). Susantha et al. (2001) proposed a method of predicting how the stress-strain relationship changes, taking into account the triaxial character of stress in concrete in tubular columns of various cross section shapes. The effect of concrete confinement has also been studied in CFST elliptical cross section columns (Yang 2008), as well as in columns of the FRP type (Yuan 2008). Analysing the problem of concrete confinement in columns consisting of steel tubes of rectangular cross sections often aims at assessing how to account for the confinement effect in calculating the load-bearing capacity of such columns so as to comply with current standards. For safety reasons, the effect that the complex character of stress distribution in concrete has on enhancement of load-bearing capacity in rectangular cross section tubular columns is most often disregarded, and accounted for only in circular cross sections. That problem was explored by many researchers. A method of computing load-bearing capacity for rectangular cross section CFST columns was suggested in (Yan-sheng Huang 2008), and the results were compared with computations according to American standards and the Chinese standard. In the same source the state of knowledge was established with particular regard to analytical and experimental research being conducted at present in numerous research centres concerning the issue of concrete confinement in composite columns.

2. Evaluation of concrete confinement in various types of composite columns

Destruction in stub columns is connected with crushing of concrete. Nonetheless, the mechanism of destruction depends directly on the behaviour of both materials constitutive of the composite cross section. Thus, the behaviour of concrete should be analysed with regard to the interaction between steel and concrete as the load increases, and the type of composite section considered has prevailing influence on the relationship between the behaviour of concrete and the introduction of load.

The interaction of structured steel and concrete is particularly noticeable in circular cross section columns of CFST type. In such columns the effect of concrete confinement is absent at early stages of load introduction. That results from the fact that at low values of load, the Poisson's coefficient for concrete is substantially lower than for steel. As the load increases, lateral deformation in concrete takes place, exerting pressure on the steel tube. At that stage of load introduction, steel undergoes stretching, and redistribution of stress from concrete to steel is observed during tests.

In (Hsuan-Teh Hu 2003) results were presented of analytical analysis which aimed at assessing the effect of adopting particular solutions in design of CFT columns on enhancement of concrete strength with regard to the complex character of stress distribution. Three types of cross sections were examined (Fig. 1), with different dimensions of the cross sections and thickness of the walls *t*.

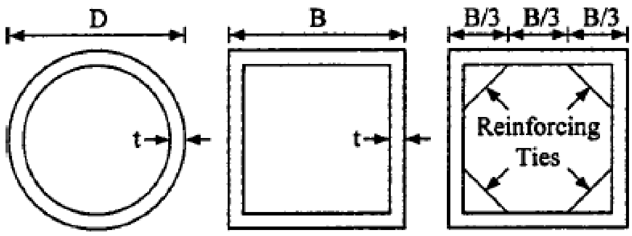

Fig. 1. Cross-sections of tested columns (Hsuan-Teh Hu 2003)

The conducted analysis confirmed that using circular cross section tubes benefits the state of stress distribution in concrete. However, that concerns the cross sections in which the relation of diameter to thickness of the plate does not exceed definite values, namely, when $D/t < 40$. In columns of a square cross section, the effect of confinement is reduced when compared with that in circular tubes, particularly ones with thinner walls, i.e., when $B/t > 30$. In those, there is a potential danger of local buckling of the steel plate. The suggested remedy in such cases would be introducing additional reinforcement to improve stiffness of the element.

In the 60ies, Rüsch and Stöckl (1969), proposed a relationship between the helical reinforcement steel and the corresponding increase of confined concrete strength f_{cc}. The relationship was expressed with the following equation:

$$f_{cc} = f_c + k \cdot p \tag{1}$$

where: f_c is the strength of concrete in the uniaxial distribution of stress, k is a factor dependent on the internal friction angle of concrete, and p – lateral strain on the interface of the concrete and the circular hoop reinforcement.

Eq.(1) presented resulting from the triaxial character of stress in concrete, is also applicable with regard to circular section composite columns. The provided value of maximum radial pressure depends principally on boundary values of ductility of steel in the tube as well as on the tube dimensions. Generally, the value of the pressure is dependent on geometrical properties of a cross section (Fig. 2). The interrelations required for calculating pressure in box section and octagonal section tubes, which are given in Fig. 3, have been modified according to formulas standing for circular sections (Susantha 2001).