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Work Theme B: Structural engineering on modern steel construction
B1 Effective use of high performance steel materials - Q690 ~ Q960

Project Title:

a) **"Effective High Strength Steel Construction for Sustainable Infrastructure Development in Hong Kong"**

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Project Outline:

In order to fully exploit potential structural efficiency offered by high performance steel materials in construction, complementary design methods should be developed to enable rational engineering design by design and construction engineers. The following research and development projects were conducted:

- Mechanical properties of high strength steels and high strength welded connections

  Material properties of high strength steels are the basis of research studies on high strength steel members. Experimental investigations with advanced "Digital Image Correlation Technology" were conducted to measure the real-time true stress-strain field in full deformation range, including the necking deformation range until fracture, by comparison against the grayscale relationship between the sub-images before and after deformation. Meanwhile, the micro-structures across the fracture surface were investigated to assess the crack growth and formation mechanism. According to texture of the microstructures, the fracture surface can be classified into three regions, namely i) shear zone; ii) radial zone, and iii) nucleated zone. Through the monotonic tensile test, mechanical properties were acquired and they were compared quantatively with different steel grades. With the measured strain field data and instantaneous geometry of the test specimen, full true stress strain characteristics have been captured for subsequent development of constitutive models for high strength steel materials, weld metals and the heat affect zones (HAZ) in welded sections.

- Residual stresses in welded sections using high strength steel materials

  The residual stress is generated from the temperature difference due to various cooling rates in the steel structural members. It gives negative impact on the design strength and behaviour of structural members. Hence it is necessary to establish the distribution and magnitude of residual stress within welded H-sections according to the requirements of the Eurocode EN 1993.

Typical residual stress patterns in welded sections made of S235 to S355 steel plates were investigated by many researchers over the past few decades. Afterwards, simplified residual stress patterns for welded sections was recommended by various design standards. In general, welding-induced residual stresses substantially induce initial geometrical imperfections in welded H-sections, and allowance to the presence of these residual stresses should be made in assessing resistances of these sections as columns or beams. However, the simplified residual stress pattern given in the ECCS are generally considered to be not suitable for welded H-sections of S690 steel as the amount of the steel materials yielded due to welding is substantially smaller than those in welded H-sections of S355 steel. Thus, it is very important to carry out both experimental and numerical investigation into residual stresses in welded sections using high strength steel materials.

- Welding parameters and procedures for effective welding of high strength steel welded members and joints

  Welding in high strength steel materials is always a concern to design and construction engineers because heating / cooling cycles will do away a large portion of strength enhancements when the heat input is not being controlled properly during welding. Hence, in order to provide technical guidelines on effective welding, a systematic investigation into various welding parameters and procedures is conducted. A robotic welding system is employed to prepare coupons of steel plates and welded sections, and standard tensile tests are carried out on these coupons to assess any variation in their strength and ductility according when they are prepared with different welding parameters and procedures.

- Experimental and numerical investigations on combined compression and bending of high strength steel welded members

  Since structural members fabricated using high strength steel material is more prone to buckle under combined compression and bending, the design methods of structural members with normal strength steel is not applicable. Thus, it is essential to conduct physical testing and numerical study, as appropriate, according to the requirements of Structural Eurocode EN 1993-1-1 to investigate buckling behaviour of high strength steel welded members.

These research projects will generate understanding and data on the structural performance of high strength steel members, and design methods on their effective use in construction will be developed in subsequent projects.