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ORIGINAL ARTICLE

Effect of the Current and Pressure on Weld Strength for IBS Rebar Machine

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ABSTRACT – The increase of population results to the increase of housing in Malaysia. One of the technologies of building houses is using the technique of prefabrication by manufacturing the walls, roof and pillars in factory and assembling the part at the construction site. This research is to study the effect of pressure and time on weld strength of IBS Rebar. In conducting the study, the data for the parameter was collected from the IBS fabrication site in Mahligai Idaman in Kota Bharu, Kelantan. The machine used spot weld to joint the concrete rebar together to make the structure of prefab. The parameter that were taken for this study are current and pressure. The result showed the effect of current and pressure to Ultimate Tensile Stress and Young Modulus. These result suggest that the effect of current and pressure significantly affect the strength of the weldment of the spot weld. On this basis, the parameter of current and pressure need to be account when run the IBS rebar machine.

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Spot weld

INTRODUCTION

The consumption of global raw material is vigorously increasing parallel with the rapidly increasing of global population [1]. The building industry has the highest raw material used of all industry sectors, and concrete industry is its largest subsector. The production of cement has triple in the last 25 years and it keep increasing [2]. Accordingly, the maximization of the concrete usage for construction material is important. The prime objective is to operate construction as little material and energy as possible while maintain and improve the safety and long-lasting building structure. Nowadays, Industrialized Building System (IBS) or prefabricated structure is increasing in market because of the construction efficiency, stable performance and consistency on durability. Prefabricated structure has been used since ancient times. In ancient Sri Lanka, prefabricated structure is used to build large structures that has date over 2000 years. There were some section that were fabricate separately and later fitted together. In the Portuguese capital after the Lisbon earthquake in 1755, the building was from prefabrication construction under the order of Sebastião José de Carvalho e Melo or well known as Marquis de Pombal. He introduced building style call Pombaline style that has a design feature of anti-seismic and innovate the prefabrication construction methods. Prefabrication construction was also widely used in construction of houses in the 20th century. In United Kingdom, this method is use as a temporary housing in urban area during World War II. Part of the partition or section of the house was fabricate in factory and assemble on site make it saved time [3].

In recent years, prefabrication construction also used in the construction of apartment blocks and house development that use repeated house unit. This is an important part in the industrialization of construction [4]. Commonly, the joints in prefabricated structures are important. This can be classified in two types; dry joint and wet joint. In a way, precast piece are assemble using bolting [5-7], while in the other type are joint that are made up of cast-in-place concrete [8-10]. Post cast concrete in wet joint is used for binding different precast concrete member and steel fiber reinforced high-strength concrete (HSFRC) is more commonly used than normal concrete for assuring the strength and structural integrity. This prefabricated member loading capacity are depends on the strength of different types of concrete and the binding effects among concrete, steel fibers and rebar. The macroscopic properties of concrete highly depend on the microstructures which contain random feature over a wide range of length scales [11-13]. In quasi-brittle material, the fracture of concrete is backed by a fast strain-softening process [14-15]. The failure zone is hugely localized, showing the so-called strong discontinuous behavior. The strain as well as displacement fields are discontinuous. Conventional continuum-based methods are not suitable for simulating the damaging process of concrete members. To solve this problem, different numerical approaches can be used like extended finite element method (XFEM) [16-18], combined finite-discrete element method [19-21], cracking element method [22-26], lattice spring models [27-29], and cracking particle methods [30-33]. With all the analysis of concrete members, there still exist some unignorable numerical problems such as numerical stability, mash bias and high computing efforts when dealing with concrete members reinforced by rebars and fibers when multiple macro and micro-crack will appear during damaging. The rebar will help to support the concrete structure. The most common type of rebar is carbon steel with round bar and a deformation patterns. The aim of this research is to find the optimize parameter for jointing in prefabricated reinforced concrete bar using IBS Rebar machine.

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There are various different classification on IBS, such as Panellised System, Onsite fabrication, Sub-assembly and components, Block work system, Volumetric and Modular System, Hybrid System and Frame System (precast or steel). The study focuses on Modular system and frame system. The modular system make the onsite fabrication move to a factory that will make the wall and beam. The precast concrete frame, steel frame and prefabricated wooden frame are combine under frame system, makin the structure rebar and filling the concrete into an open system. The standardization of IBS classification will be useful for industry player that will have the same measurement and technical term to make the IBS. The frame system that are used onsite are the precast wall and steel frame. Both of the material use the same system that most of the part are made in the factory and assemble or joint onsite to decrease labor work and reduce time. The part also been made in a control environment to make sure the finish precast are quality and safe. This process also contribute a cleaner and well-ordered environment at the site [34]. The material that are used in a precast are concrete, structure steel and steel reinforcement.

Concrete are the main material that are used in building today due to its low maintenance and high structure rigidity. Concrete will take 24-48 hours for the concrete to be harden but for the concrete to have it full strength it will take 28 days to cure [35]. The factors that make concrete strength are cement strength, water content and water to cement ratio. Since the concrete are expose to the environment, over time the water in the concrete evaporate and make the concrete wall stronger and will last over the life of the building. Precast concrete have the advantage of curing in a control environment from the cast to the fully strength concrete. The precast concrete also have the benefit of compacting the concrete in a control system. This will make sure the density of the concrete are up to standard. Precast concrete also can be test to see the breaking point of the concrete in a safe environment.

METHODOLOGY

The process of making IBS samples are performed in two stages; the manufacturing at a factory condition and the area that building are build. The preparation of this required are casting and curing in the factory and the building site [36]. Casting is the first stage of this process. The precast are made at the factory with the bending and welding of the reinforce rebar to the shape that is needed. Then the reinforce rebar are put in to a mould to be cast. Next the concrete are pour in the mould. A vibrator are used to vibrate the concrete to remove any air pocket in the mould. The mould then place to be cure. Curing process is the process of let the concrete set. The concrete are hard in 24-48 hours after casting. After the concrete are hard the mould are open and let the concrete to set. Concrete need to left for 28 days to let the water evaporate for the full strength of the concrete to be set. After the concrete are cure, the IBS is transport to the building site to be assemble.

Figure 1 shows the welding part of the welding-bending machine. This machine is tailored to automate the welding process on the concrete rebar. This machine used spot welding technique to simplify the mechanical work for a machine. It have four spot welding, an input table, an output table and an automated pulling system to pull the concrete rebar. It have a maximum current of 90 amp that can be control on a touch-screen display. The machine also have a pressure gauge to indicate the pressure force on the spot weld. The machine also have a time setter for applied pressure and lead current on the concrete rebar.

Figure 1. Welding-bending machine

The parameters of interest are current and pressure that are applied to the specimens during the spot welding process in the IBS fabrication. In the collection of the samples, if the weld spots in the concrete rebar are below 40% on a cycle will be not considered to be a parameter value of interest. The first parameter that was studied is current and the range are 70,75,80,85 and 90. Each range need to have 8 to 20 sample in a cycle. When the range at below 70, the sample size decrease to below the number of sample that need to collect. Most of the weld do not have contact with the concrete rebar. This is the same with the range of current above 90. The second parameter that was studied is pressure. The range for pressure are 5 bar, 6 bar and 7 bar. A fabricated sample is as shown in Figure 2. The samples will then be cut into smaller specimens for the purpose of mechanical testing. In mechanical testing, both the Ultimate Tensile Strength (UTS) and Young's Modulus were studied.

Figure 2. sample of welded concrete rebar

RESULT AND DISCUSSION

The Effect of Current

Figure 3 shows the effect of current magnitude to the Ultimate Tensile Stress (UTS) of the rebar weldment. The result of sample 1 to 5 are taken for the current variable. The constant variable for sample 1 to 5 are preheat current, preheat time, weld time and pressure that are set 90A, 3s, 5s and 7bar respectively. From the figure, it is observe that the UTS increases with current until peaked at current 80A, and eventually decreases from thereon. It can be deduced that the highest Ultimate Tensile Stress are 13.552 MPa when the current of 80 A. While the lowest Ultimate Tensile Stress are 9.84 MPa when the current of 70 A.

Meanwhile, Figure 4 shows the effect of current to Young's Modulus. From the figure, it is observe that the Young Modulus increases with current until peaked at current 85A, and eventually decreases from thereon The highest Young Modulus are 403.614 MPa when the current of 85 A. While the lowest Ultimate Tensile Stress are 261.582 MPa when the current of 70 A. UTS and Young's Modulus are affected by applied current in similar manner, where the optimal current is in the range of 80A to 85A. The current that is lower than the optimal range will not have enough heat to melt the rebar steel, thus the weldment will not optimally bonded by the weldment. However, if the current is too high, the weldment upon solidification, will experience high cooling rate thus the weldment will be more brittle and results in lower UTS and Young's Modulus.

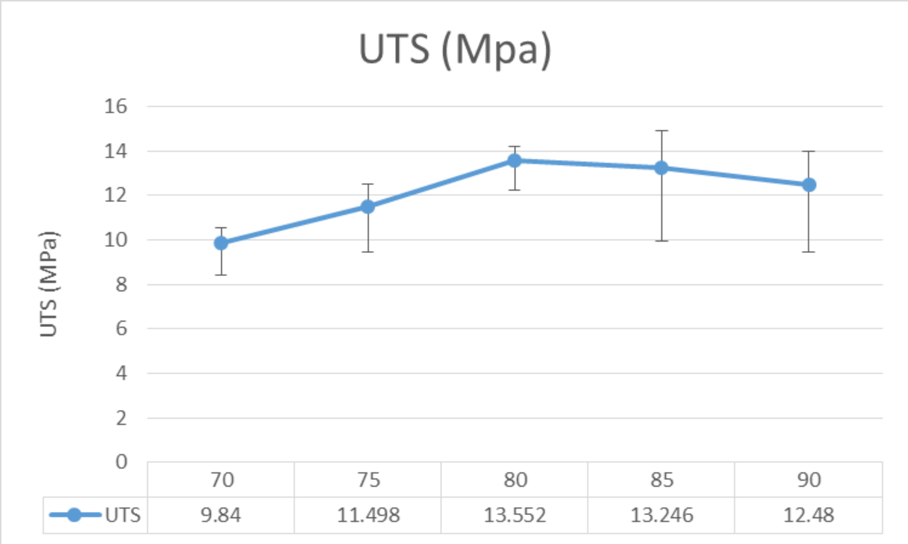

Figure 3. The effect of current to Ultimate Tensile Stress

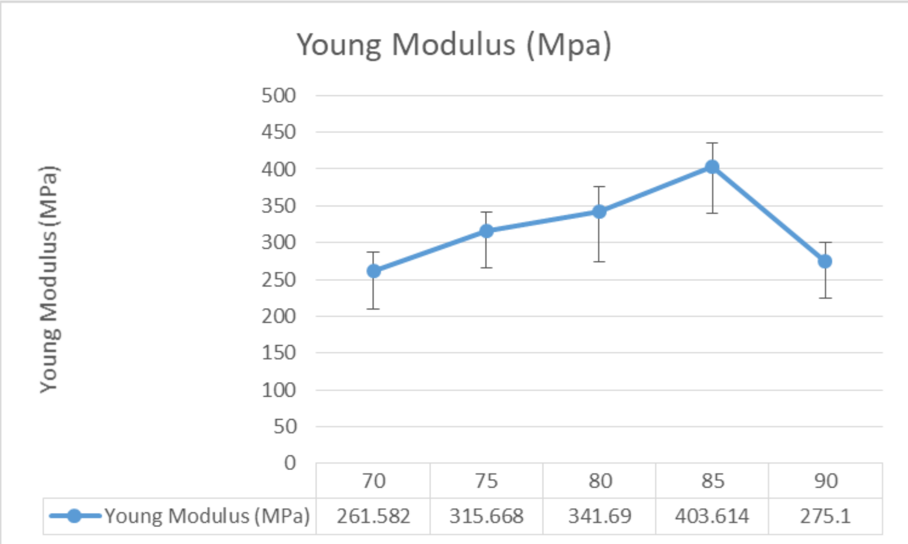

Figure 4. The effect of current to Young's Modulus

The effect of pressure

Figure 5 shows the effect of pressure to Ultimate Tensile Stress of the rebar weldment. The constant variables for the samples are preheat current, preheat time, current and weld time that are set 90A, 3s, 75A and 5s respectively. From the figure, it is observed that the pressure has little effect on the UTS of the weldment. However, it exhibits an improvement upon incresing the pressure of the spot weld, despite insignificant. The highest Ultimate Tensile Stress is 11.498 MPa when the pressure is 7 bar. While the lowest Ultimate Tensile Stress are 10.656 MPa when the pressure is 5 bar.

Figure 6 shows the effect of pressure to Young's Modulus of the rebar weldment samples. For this parameter, the constant variables are preheat current, preheat time, current and weld time that are set 90A, 3s, 75A and 5s respectively. From the observation, the Young's Modulus peaks when the pressure is at 6 bar. The Young's Modulus is lower when the pressure is both lower and higher than 6 bar. From the study, UTS of the weldment is not significantly influenced by the pressure, while Young's Modulus of the weldment is significantly affected by the applied pressure. However, more data at different applied pressure is needed to safely conclude that 6 bar is the most optimal pressure to be used for the rebar weldment in IBS fabrication.

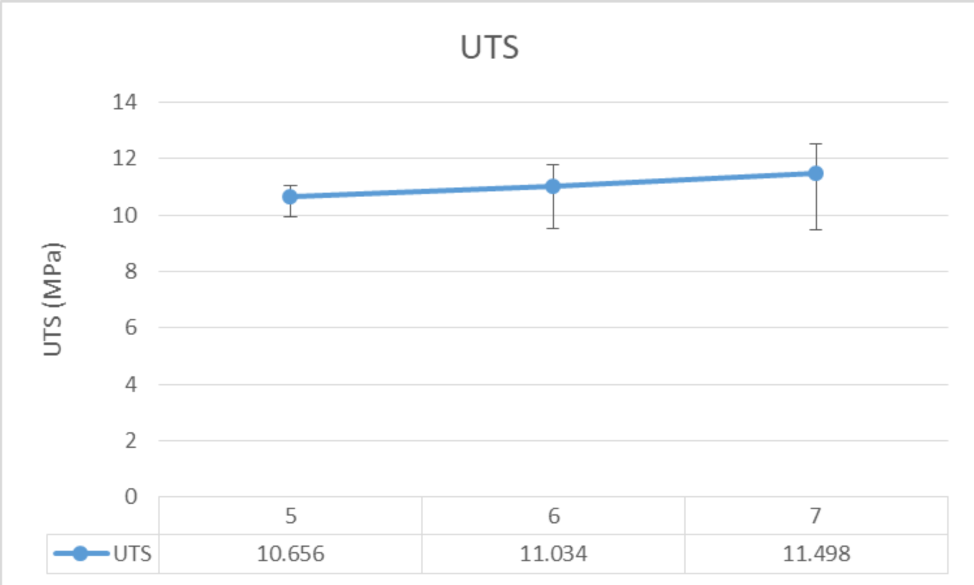

Figure 5. The effect of pressure to Ultimate Tensile Stress

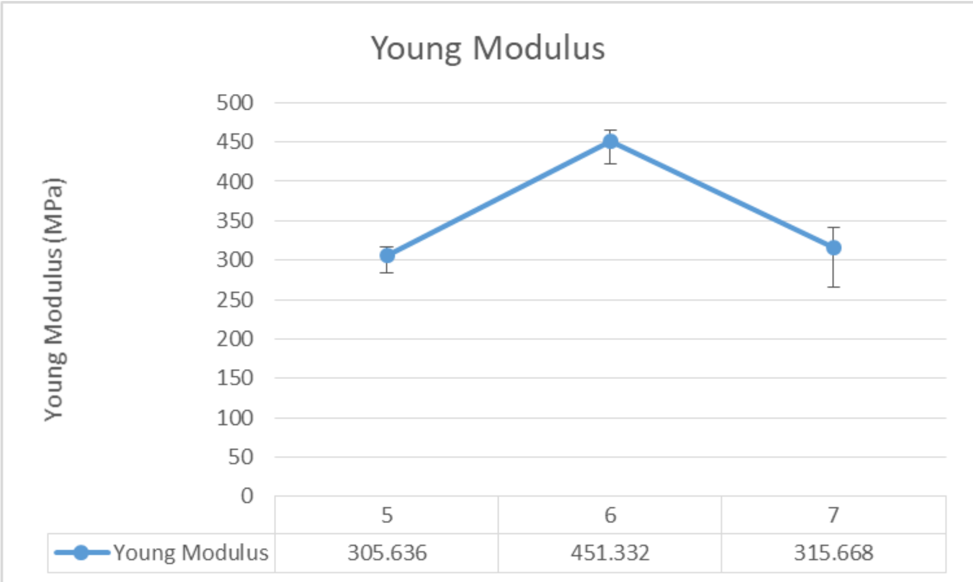

Figure 6. The effect of pressure to Young's Modulus

CONCLUSION

This study are done to find the optimal parameter of the welding-bending machine. The result of the mechanical testing shows that the optimal parameter for the welding-bending machine is when the current is 80-85A and applied pressure is 6 bar. The current significantly affect both the UTS and Young's Modulus due to the heat supply to the rebar steel and the high cooling rate of during the solidification of the weldment. While the applied pressure shows insignificant effect to the UTS of the rebar weldment. While the Young's Modulus peak at 6 bar, more data at different applied pressure is needed to conclude the optimal pressure for the weldment of the rebar.

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