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# A COMPARISON OF CONSTRUCTION JOINT ABILITY ON CONCRETE SLAB APPLIED AT CONSTRUCTION SITE

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**ABSTRACT**

Construction joints are stopping places in the process of placing concrete, and construction joints are required because in most structures it is feasible to place concrete in one casting work. The amount of concrete that can be placed at one time is depend on the batching capacity and capabilities to construct formwork. A good construction joint should provide adequate flexural and shear continuity through the interface. In this study, the effect of type of construction joints on the performance of concrete structural elements is experimentally investigated. Six slab samples with dimensions of 700×400×150 mm were tested. The variables investigated are the type construction joints. All sample were tested using 100 kN computer controlled versatile electronic testing machine named as Magnus Frame. The sample was positioned in the machine so that the deflection at middle of sample measured at each load step. The results of the experimental program indicated controlled sample have the maximum applied load, deflection, stiffness and energy absorption. Sample incline joint named as joint sample 1 have the higher applied load, deflection and energy absorption compare to other joint sample, but joint sample 2 using Hy-Rib Mesh to form concrete joint have the higher stiffness compare to other joint sample. The value of joint sample 1 maximum load is 25.93kN, deflection were 0.68mm and energy absorption 8.261kN-mm, joint sample 2 have 47.36kN/mm stiffness compare to joint sample 2 which only have 34.58kN/mm. It was found that the Hy-Rib Mesh construction joint is the best joint as it have the maximum stiffness, higher stiffness of concrete have a higher characteristic of rigidity.

**Keywords:** construction joint, Hy-rib mesh, energy absorption.

## INTRODUCTION

### Overview of Joint Structure

Joints are necessary in concrete structures for a variety of reasons. Not all concrete in a given structure can be placed continuously, so there are construction joints that allow for work to be resumed after a period of time. Since concrete undergoes volume changes, principally related to shrinkage and temperature changes, it can be desirable to provide joints and thus relieve tensile or compressive stresses that would be induced in the structure. Alternately, the effect of volume changes can be considered just as other load effects are considered in building design. Various concrete structural elements are supported differently and independently, yet meet and match for functional and architectural reasons. In this case, compatibility of deformation is important, and joints may be required to isolate various members [1].

A joint in a structure or member shall be designed and constructed so the load-carrying capacity and serviceability of the structure or member is maintained while serving its intended function. Joints shall be for construction purposes (‘construction joint’) or to control movement (‘movement joint’), as appropriate [2].

Construction joints may be either planned or unplanned. Planned construction joints; the location and detailing of planned construction joints can be considered and prepared. The location should be determined in conjunction with the contractor. The contractor will be able to define the maximum size of concrete placement possible on the particular project. Unplanned construction joints; these are joints that are forced upon the concrete-placing crew because of an interruption in supply of a duration long enough for the concrete to take its initial set. There is no opportunity to plan their location of joint [3]. Joints can be made at two different times before or after. Before any concrete is poured, as for Construction joint or Isolation joint. After concrete have been placed and compacted, as for Control joints [3].

The aim of this research is to establish a qualitative and quantitative understanding deformation effect of type of construction used mostly at construction site. The objective of this research is to compare the capability of unreinforced concrete joint on site and to identify the characteristics of affecting ability of concrete joint in unreinforced concrete

### Isolation Joint or Expansion Joint

Three types of joints are commonly used in concrete slabs-on-ground: isolation joints, contraction joints, and construction joints (see Figure-1) [6].

An isolation joint totally separates a concrete element from another concrete element, or a fixed object such as a wall or column, so that each can move and not affect the other. The joint filling should be full depth and soft. It can be made of cork, foam rubber, or some other flexible material. The expansion or isolation joint is a discontinuity in both reinforcement and concrete; therefore, an expansion joint is effective for both shrinkage and temperature variations [1, 3].

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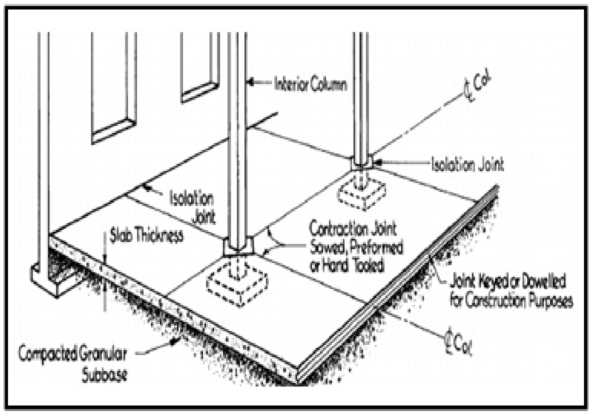


**Figure-1.** Location and types of joints [1].

All buildings are restrained to some degree; this restraint will induce stresses with change in temperature. Temperature induced stresses are proportional to the temperature change. Large temperature change can result in large stresses to account for in design. Small temperature changes may result in negligible stresses. Expansion joints are used to limit member forces caused by thermally-induced volume changes. Expansion joints permit separate segments of a building to expand or contract without adversely affecting structural integrity or serviceability. Expansion joints also isolate building segments and provide relief from cracking because of contraction of the structure [1].

**Contraction Joint**

A joint between one section of a ground-supported floor or pavement and the adjacent section to allow the shrinkage of the concrete to occur at defined locations called as contraction joint. The Joint should allow the shrinkage of the next sections to take place across the joint, preferably at right angles to the plane of the joint. Any relative vertical displacement across the joint should be prevented [3].

Contraction joints consist of a region with a reduced concrete cross section and reduced reinforcement [1]. Contraction joints are usually located on column lines with intermediate joints located at equal spaces between column lines [5]. Contraction and expansion joints within a structure should pass through the entire structure in one plane [6]. If the joints are not aligned, movement at a joint may induce cracking in an un-jointed portion of the structure until the crack intercepts another joint [1].

**Construction Joint**

For many structures, construction joints are required to accommodate the construction sequence for placement of concrete. The amount of concrete that can practically be placed in any operation is a function of the batching and mixing capacity and the time available for placing the concrete in the particular segment that is placed. The construction joint is the separating plane between the old concrete and the new concrete batch [7].

Construction joint is defined as ‘the surface where two successive placements of concrete meet, across which it may be desirable to achieve bond and through which reinforcement may be continuous’. Generally, because continuity of structural action will be required across the joint, bond will be desirable and the reinforcement will be continuous [8].

Pure construction joints are not intended to accommodate movement but merely separation between consecutive concreting operations and in fact, every effort is directed towards preventing movement from occurring at these joints. Construction joints are nearly always the weakest points in a structure. The main problem that remains therefore in the formation of a good construction joint is the capability of providing a well bonded medium between the hardened and the fresh concrete. Thus construction joints in concrete structure should be placed where shear forces are expected to be low [9].

In either case, the engineer or contractor should consider economy, appearance, strength, and durability when choosing joint location. Economy; if the contractor have input on where to put construction joints, he can match the pour size to his crew capabilities. Appearance; Construction joints can influence how a structure looks. Often construction joints are installed in an inconspicuous position. Some designers use grooves to hide the joints. Strength; A construction joint introduces a weak vertical or horizontal plane in an otherwise monolithic concrete member. This obvious slip plane may reduce the strength of beams, columns, and walls. Test results show that construction joints reduce member shear strength but not the bending strength [10].

**Joint Location**

Careful consideration should be given to selecting the location of the construction joint. Construction joints should be located where it will least affect the structural integrity of the element under consideration, and be compatible with the building appearance. Placement of joints varies, depending on the type of element under construction and construction capacity [1].

Construction joints are most likely to reduce shear strength it should be located where shear forces are low. Desirable locations for joints placed perpendicular to the main reinforcement are at points of minimum shear. Under uniformly distributed gravity loads, shear force are low in the middle of a flexural member span Construction joints in floors shall be located within the middle third of spans of slabs, beams, and girders. Joints in girders shall be offset a minimum distance of two times the width of intersecting beams but locations should be verified by the engineer before placement is shown on the drawings [1, 10, 11].

In this study all location of joint in sample is at the middle of the sample. This location selected to reduce the load applied when testing the sample, due to the ability Magnus Frame impose load.

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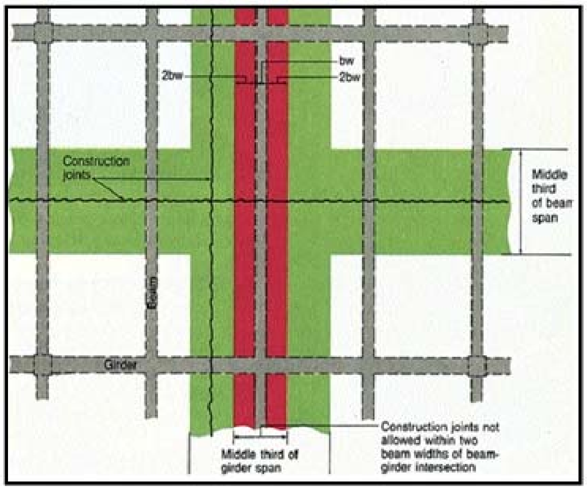


**Figure-2.** Location of joints [10].

## Hy-rib Mesh

Hy-Rib is an expanded metal sheet product, specifically developed for use as permanent formwork to concrete. The profile of the open mesh, in combination with the Hy-Rib tangs, allows the development of dense concrete nodules and indents on the face of the Hy-Rib, forming an enhanced mechanical key for the second phase pour. In the case of visible elements, the resulting Hy-Rib surface is suitable for a rendered or tiled finish. Hy-Rib is primarily used in construction joint applications but it is also used to form wall, beam and column surfaces and slab soffits, where the formed surface will not be seen [4].

Hy-Rib used in two samples in this study, the first sample will be permanently using Hy-Rib in the joint and the second one, Hy-Rib removed before conduct the second pouring.

Agrément Certificate No 93/2915 has been released by British Board of Agrément to approve the usage of Hy-Rib as permanent formwork. Hy-Rib is use as permanent formwork to form construction joint, stop ends, retaining walls and column. It also can be used to support horizontal slab flooring. Hy-Rib will produce a surface with bond directly to the next pour [12].

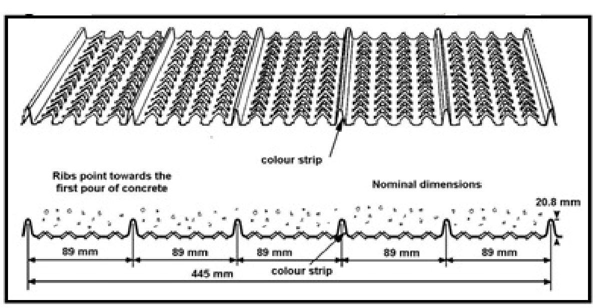


**Figure-3.** Illustration and cross section of all grades of Hy-Rib [12].

## EXPERIMENTAL WORK

### Sample Design Criteria

Consideration for sample size is based on several considerations. Basic minimum thickness of slab is 75mm as stated by ACI 302 (2004), but U.S. Dept. Of the Army (1999) state the minimum thickness of slab is 100mm. Maximum appropriate sample width of sample tested on Magnus Frame is 600mm, all slab samples being tested is 40mm. Based on calculation of sample weight, the sample have length of 0.7m the weight is about 100kg and only need two persons to lift it [5,13].

All samples joint have its own joint criteria, all joint located in the middle of sample. The second batch of mixture concrete poured after three day the first pouring. Table-1 shows the illustration of cross section of all samples.

Control 1 and 2:
Formwork cast fully either first batch or second batch.

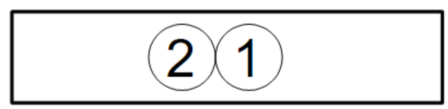


Illustration of cross section sample.

Joint 1:
Incline joint at middle sample.

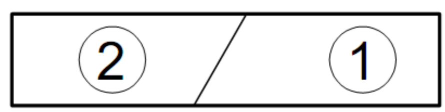


Illustration of cross section sample.

Joint 2:
Hy-Rib as permanent formwork.

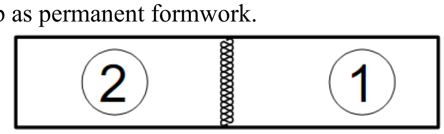


Illustration of cross section sample.

Joint 3:
Hy-Rib removed before second batch of pouring.

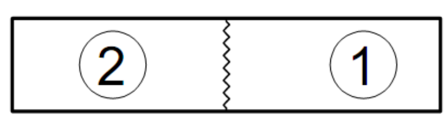


Illustration of cross section sample.

Joint 4:
Key joint at middle sample.

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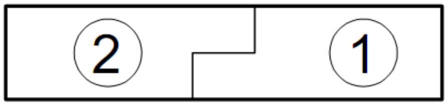


Illustration of cross section sample.

**Point Load Test**

Samples have to be prepared before it can arrange on the test machine. Sample surface cleaned and flatted to make sure the uniformity distribution of load on the sample. Location of support marked on the sample side.

All sample tested using Magnus Frame test machine, this machine have permanent frame compare to Universal Frame test machine. All samples lifted up using Forklift, then arranged on the test machine as shown in Figure-4. Linear Differential variable Transformer (LVDT) placed below the sample level and ensure sample not fall on the LVDT when sample fall.

**Figure-4.** Test arrangement on magnus frame with LVD placed below the sample level.

**RESULT AND DISCUSSION**

Deflection Load curve for all sample compared to both sample control on and control two shown in Figure-5. From the curve shown, all deflection not satisfied the ultimate deflection design for plain concrete. Maximum deflection value is 0.68mm for joint sample one then followed by both control samples. Joint sample two have the minimum value of deflection followed by joint sample four, both samples have deflection less than 0.3mm. Both control samples have the maximum load followed by joint sample two.

Stiffness is the ability of structure to resist deformation under imposed load [15]. This structure behaviour is very important to compare the joint ability on slab. The gradient of inverse deflection versus load curve is equal to the stiffness of sample. The graph in Figure-6 shown, both control samples have the maximum stiffness followed by sample joint two, despite the sample joint two have small maximum load value. The curve shown sample joint three have the smaller stiffness followed by sample joint 4.

Strength is equal to the energy absorbed by the sample before if failure. In this analysis energy absorption obtained by compute area under the curve Load (kN) versus Deflection (mm). Using first degree of integration method, area calculated from graph equation and the lower limit assume as zero due the deflection value is zero when load is zero then the upper limit is maximum deflection of sample before sample failure (see Table-1). From the calculation showed, both control sample have the maximum energy absorption and followed by sample joint one. Other joint sample show small value of energy used to foil the sample.

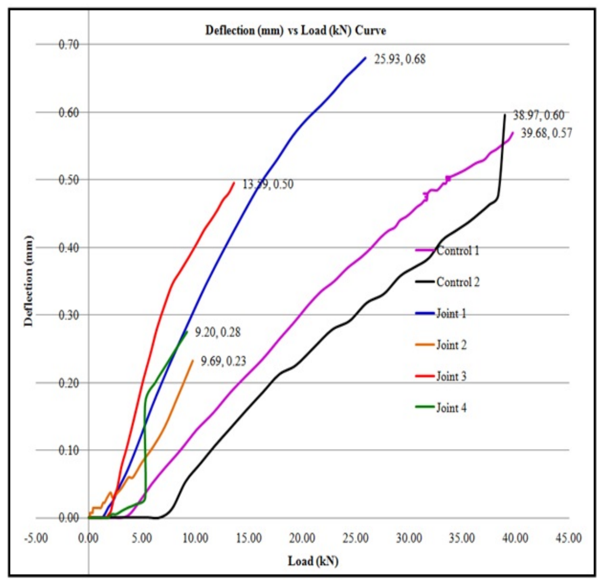


**Figure-5.** Deflection (mm) vs. load (kN) curve.

**Table-1.** Calculation for energy absorption (kN-mm).

| Sample | Graph Equation (y) | Upper Limit (mm) | Integration of (y) (kN-mm) |
|---|---|---|---|
| Control 1 | 65.38x + 0.727 | 0.57 | 11.035 |
| Control 2 | 76.38x + 1.408 | 0.59625 | 14.417 |
| Joint 1 | 34.58x + 0.391 | 0.68 | 8.261 |
| Joint 2 | 47.36x + 0.143 | 0.2325 | 1.313 |
| Joint 3 | 24.27x + 0.528 | 0.495 | 3.235 |
| Joint 4 | 29.99x + 0.762 | 0.275 | 1.344 |

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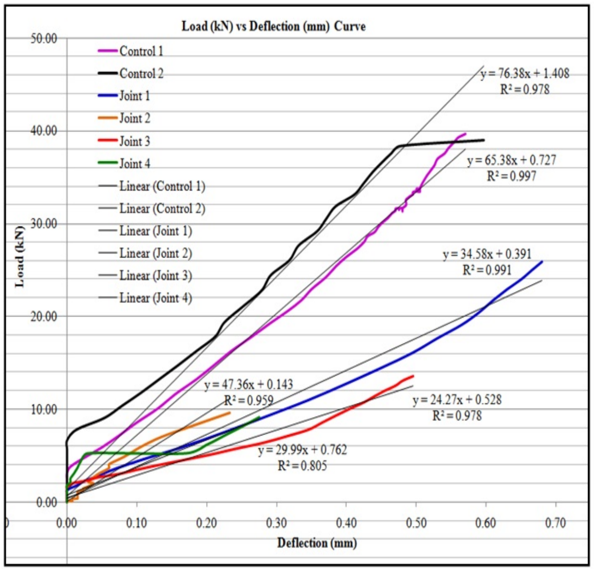


**Figure-6.** The gradient of stiffness curve (kN/mm).

## CONCLUSIONS

From these studies, it was shown that usage of Hy-Rib Mesh in construction joint is not a waste method. Despite the incline construction joint have the maximum value for imposed load, deflection value and energy absorption, usage of Hy-Rib Mesh is more practical regarding of higher stiffness value. The more stiff a structure element the more high it rigidity behaviour.

It can be concluded, the higher value for incline joint due to the location of joint is not accurately at the middle sample, moreover the sample have the higher thickness compare to other sample. Both control samples achieve the standard as control sample since all result show both of it have higher value than other sample.

Other consideration effect the result data is usage of vibrator, while casting both pouring work is not completely vibrated due to the machine was in maintenance. Surface preparation before arranged sample on the Magnus Frame test machine is not completely flatted, no specific tool can be used to make sure the surface is uniformly flatted and it only verify by observing the surface.

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