YIELD CURVATURE OF CIRCULAR REINFORCED CONCRETE SECTIONS

Vinicio A. Suarez

Objective

Show the relation between yield curvature, yield moment and flexural stiffness of reinforced concrete circular sections.

Background

Most of buildings and bridges are designed to exceed their elastic limits when attacked by the design earthquake. Exceeding elastic limits for reinforced concrete sections means cracking of concrete, yielding of reinforcement, crushing of concrete and eventual collapse of the section.

The nonlinear flexural behavior of reinforced concrete sections can be assessed by a special type of section analysis called Moment-Curvature analysis. The outcome of this analysis is the relation between applied moment and related curvature in the section. Other very important information is the relation between curvature and concrete strain, steel strain and neutral axis depth.

The theory of beam flexure states that curvature is the second derivative of displacement. Moment-curvature relation is then very important since gives the correspondence between moment and curvature necessary to the calculation of displacements due to forces acting in inelastic elements. Furthermore, it allows the assessment of displacement at different limit states of damage.
Figure and different points

Material models

Moment-curvature relations can be well fitted with bilinear diagram. This is commonly done to easy the calculations based on the moment curvature relation. There are several methods that have been proposed for this task. One of the most common consist in a having a line starting at the origin and passing by the point of first yield, and other line that starts in the point of failure and that cuts the first line in a point where moment equals the nominal moment of the section. The point at which the two lines intercept sets the yield curvature and yield moment of the section. The slope of the first line gives the cracked flexural stiffness EI of the section. The yield curvature in and important inherent property of the section that is used in the computation of yield displacement and damage indexes such as ductility.

Most of design codes implicitly assume that My is independent of EI and therefore My and fy are directly proportional. This is realized when using fixed inertia reduction factors to compute a cracked inertia that is used to calculate the stiffness of the structure. These inertia reduction factors do not depend on the amount of reinforcement that it is in the element.

Virtual Setup

To run this experiment the user is directed to the virtual setup for **Moment-Curvature response**. This setup allows the definition of circular concrete sections and the determination of the moment-curvature relation, its bilineal approximation and other relevant information.

Method

To achieve the objective of this experiment, it is suggested to conduct a parameter study to observe the relation between fy, my and EI for a range of different columns. The procedure is as follows:

1. Define at least 10 different reinforced concrete circular sections. It is important that at least the diameter, longitudinal reinforcement and axial load be varied among the columns. The following table can be used as template:

Analysis		1	2	3	4	5	6	7	8	9	10
SECTION PROPERTIES	SECTION DIAMETER D(mm)										
	COVER r (mm)										
	LONGITUDINAL REBAR DIAMETER dbl (mm)										
	# LONGITUDINAL REBARS										
	TRANSVERSE REBAR DIAMETER dbt (mm)										
	Spirals Hoops TRANSVERSE REINFORCEMENT TYPE										
	SPACING OF TRANSVERSE REBAR et(mm)										
MATERIAL PROPERTIES	UNCONFINED COMPRESION CONCRETE STRENGTH f'ce (Mpa)										
	YIELD STRESS OF LONGITUDINAL REBAR fy (Mpa)										
	YIELD STRESS OF TRANSVERSE REBAR fyh (Mpa)										
	ULIMATE TENSION STRENGTH OF LONGITUDINAL REBAR fu (Mpa)										
	AXIAL LOAD P (KN)										
	ELASTIC MODULUS OF STEEL (MPa)										
	ELASTIC MODULUS OF CONCRETE (MPa)										
	YIELD STRAIN OF LONGITUDINAL REINFORCEMENT										

2. Go to the virtual setup Moment-Curvature response and perform the analysis for each of the columns.
3. Obtain a report of the analyses
4. Analyze the data in Fig. 2 and Fig.3.
5. Post your conclusions and comments

Questions

1. The following equation has been suggested for estimation of yield curvature of reinforced concrete circular sections (Priestley,). Do your experimental results validate this equation?
2. What are the main factors affecting the yield curvature?
3. Is it necessary to know the reinforcement of a section in order to compute the yield curvature?
4.Is it necessary to know the reinforcement of a section in order to compute the flexural stiffness EI?