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RELIABILITYOFREINFORCEDCONCRETEBUILDINGSDURINGCONSTRUCTION

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Abstract: The safety analysis of reinforced concrete buildings during construction should be based on thecomprehensive understanding of loads, load effects, structural resistance, and available safety index of thestructure. This paper analyzes the characteristics and probabilistic models of resistance, loads, and load ef-fects. A method was developed to calculate the probability of failure based on Monte Carlo simulation andmodels proposed in previous articles. Construction examples were used to analyze the influence of live loadon the probability of failure. The results show that when the live load increases, the maximum probability offailure increases with acceleration. The results suggest that the construction live load should be carefullyaddresseddduring construction.

Keywords:reinforcedconcretebuildings;duringconstruction;loadredistribution;failureprobability

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Introduction

The characteristics of resistance, load, load effect, andfailure mode should be taken into consideration whenanalyzing the structural safety of reinforced concretebuildingsduringconstruction,whichwerereferredtoastemporary or time dependentstructures.
Lew[1] identified three different types of load com-binationsduringdifferentconstructionstages,andpointed out that the load distributions on different floorslabs must be considered. Karshenas and Ayoub col-lected construction live load data from 24 constructionsites[2]andtheyanalyzed[3,4]thedataandconvertedthe live loads into an equivalent uniform distributionload(EUDL)usingtheinfluencesurfacemethodtomake the construction safety analyses more convenient.Mesh sampling of the construction loads on a floorplane showed that the Weibull, log-normal, exponen-tial, and gamma distribution probability models wereacceptable, with the Weibull distribution as the best.The construction loads are presented as a compositedistribution that is a combination of a zero load and acontinuous nonzero load distribution. The EUDL prob-ability model and the load effects can be described bythesame distribution.

LOADS AND LOAD COMBINATIONS

During the construction of reinforced concrete build-ings, each construction cycle can be divided into threemajorstages:thecastingstage,thecuringstage,andthe shore removal stage. During the casting and shoreremovalstages,theloads on thestructurememberschange suddenly. During the curing stage, a transitionappears between the casting and shore removal stages,and the loads and properties of the structure memberschangesmoothly.Many researchers analyzed loads during construc-tion but their conclusions differed due to different datasetsanddifferentdataprocessingmethods.Table1lists various probabilistic models and parameters thathave been used in the literature. In this paper, the loadsare defined as follows.

DEAD LOAD

Dead loads include the weight of the reinforced con-crete members, the formwork, and the shores. For theweight of the reinforced concrete members, the ratio ofthe mean value to the standard value of the weight isassumedtobe1.06,andthecoefficientofvariationis0.074 With a normal distribution[18]

OCCASIONAL LOAD

In addition to normal loads, specific construction ac-tions may induce occasional loads on the temporarystructures. These occasional loads, such as heavy ma-chineryorextraordinarilyheavymaterialputonthetop floor, should not be included in the normal liveloads,buthavetobeconsideredinspecificcircumstances.

LOAD EFFECT

The construction load effect can be obtained by ana-lyzingtemporarystructuressubjecttoconstructionloads [16]. However, the construction load effect is verycomplex because the structural configuration and theconstructionmaterialcharacteristicsareconstantly

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MATERIAL PROPERTY UNCERTAINTIES

Constructionmaterialpropertyuncertaintiesresultfromthevariationofthestructuralperformanceof the development and the probability distribution ofthe concrete strength during curing were investigatedby measuring concrete strength of 275-cubic concretesamples fabricated for five different design strengths at3 d, 7 d, and 28 d. All the samples were grouped in ac-cordance with their design strengths and age with theirstrength converted toin-placestrengths according tothe Chinese concrete code[24], as shown in Table 3. Theresult was then used in the computational examples inthis paper with the concrete strength assumed to followanormal distribution.

Table3Probability distribution parameters for initial concrete strength

Typeofcement	Age (d)	Mean value(MPa)	Standarddeviation(MPa)	Variationcoefficient
Portland-slagcement				
C10	3	7.67	2.64	0.34
	7	13.11	3.47	0.26
	28	20.17	4.84	0.24
C15	3	10.03	2.66	0.27
	7	15.84	3.52	0.22
	28	25.31	5.78	0.23
C20	3	12.14	2.71	0.22
	7	20.43	2.61	0.13
	28	29.48	3.85	0.13
C25	3	14.65	2.96	0.20
	7	23.68	2.92	0.12
	28	34.83	4.55	0.13
C30	3	17.59	3.31	0.19
	7	26.78	3.31	0.12
	28	40.26	1.29	0.03

CONCLUSIONS

A new structural analysis model was used to develop astructuralreliabilityanalysismethodtopredicttheprobability of failure for reinforced concrete buildingsduring construction. The analytical method was alsoused to analyze the impact of the live load on the prob-ability of failure. The results show that when the liveload increases, $P_{f,max}$ increases with acceleration. Theconstruction live loadshould be carefullyaddressedduring construction.

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