CONTRACTOR SELECTION MODEL IN COMPETITIVE BIDDING SYSTEM

Yusuf Joe Gandu[1], and Yakubu Micheal Zaki[2]
[1] Department of Quantity Surveying, Faculty of Environmental Sciences, Bingham University, Abuja-Keffi Expressway, Nasarawa State Nigeria. e-mail: yusufgandu@yahoo.com
[2] Department of Quantity Surveying, Faculty of Environmental Sciences, Kaduna State University, Kafanchan Campus. e-mail: yakubuzaki2@yahoo.com.

ABSTRACT
The lowest bid has often been favoured for award of contracts in competitive bidding. Despite the fact that the essence is to achieve value for money for the client, studies show that the lowest bid doesn't often guarantee cost efficacy of construction projects. Different models have been developed to improve on the lowest bid award system. Some of the research results produced regression models that will identify not just any lowest bid but the lowest responsive responsible bid among bidders. However, the independent variables in such equations raise some questions that demand answers from research consideration. The major questions were the rational on the choice of variables and the reasons for using only two independent variables in the equations. This research is set to consider those questions in developing a more reliable regression model that will identify the lowest responsive responsible bid in competitive bidding. Water engineering projects competed in the north eastern part of Nigeria between 2015 and 2017 were used. Thirty six (36) completed projects of diverse magnitudes involving 220 bids with diverse level of competition were used. Three new regression models were developed, two of which has 3 independent variables and one has 4 intendant variables. Both were compared with earlier similar equations developed with 2 independent variables. It was found that different matrixes of independent variables presented different predictive power of the lowest responsive responsible bid. Comparison shows that the equation with 4 independent variables is the most robust predictor of the lowest responsive responsible bid. However, for the sake of convenience and early identification, the optimum equation with 2 variables containing the number of bids and the consultant's estimate was recommended. This is in line and justifies earlier research recommendations. It is expected that the result will enable quick identification of bon-a'-fide contractor at the early stage of the bidding process through which the cumbersome task of bid analyses will be reduced, as such cost and time of bidding also reduced.

Key words: *competitive bidding system, contractor, construction projects, lowest bid, model*

INTRODUCTION
Bidding has been and will continue to be important construction undertaking by virtue of its positive contributions to the procurement process (Alumbugu, Ola-Owo, Saidu, Abdullahi, & Abdulazeez, 2014, Oyeyipo *et al,* 2016, Bruik *et al.,* 2017). To the client, bidding is a pre-contract activity that aids in the selection of a competent contractor to handle on his behalf, the construction of a facility called construction project (Aje *et al,* 2016). Getting a competent contractor is vital to any construction project success (Zavadskas *et al,* 2008). There are techniques developed for construction contractor selection (Azeez & Aboelmagd, 2019), among which is the lowest bid system (LBS) (Khan & Khan, 2015). The LBS relies extensively on the lowest price offered by a contractor among competitors as basis to award contracts (Gandu *et al,* 2020). The essence of LBS often cited has been for the purpose of cost savings via reduced contract awarding amount of a project for better value for money invested by the client (OECD, 2011). However, studies have found that the LBS does not guarantee cost savings at the long run in the life of a project (Puri and Tiwari, 2014, Hafez *et al,* 2015). Kim and Skibniewski (2020) argued that there's likelihood unsuccessful higher bid figures justifiably convey more important information than the successful lowest bid,

the information of which will benefit the entire construction process of the proposed project. Such information relating to uncertainties noticed by the bidders could be glossed over by the owner like the scope of work or field conditions not fully considered; or more risk factors becoming visible thus justifying a high offer by a contractor but were overlooked by the lowest bidder. Researchers have therefore tried to find ways to enhance the LBS during contractor selection through models developed to improve the system (Carr, 2005, Gandu *et al.,* 2020). The models have tried to achieve not only the identification of the lowest bid at the early stage of a bidding process, but that the lowest bid must be responsive and responsible that guarantees successful contract implementation (Carr, 2005, Gandu *et al.,* 2020). However, the optimum is yet to attain along this backdrop and there are calls for more research consideration in the field of bidding. For example, Carr (2005) used the number of bidders and the consultant's estimate in the development of a model to predict the responsible lowest bid. Gandu*et al.* (2020) observed that there was no rationale in choosing the two independent variables in Carr (2005)'s equation since there exists other variables that could improve the equation. The researchers believed that Carr (2005) should have tried other independent variables to find which one is most robust in the predictive goal. Gandu*et al*. (2020)'s research then identified four variables which were usedinmodelling seven regression equations to predict the lowest responsiveresponsible bid in competitive bidding system. The models generated had either one or two independent variables in each equation only.Comparison of the models found that different matrixes of theindependent variablesdepicted different predictive strengths in identifying the lowest responsive responsible bid.The researchers recommended a model for application in bid selection, but suggested for more research efforts along this line, believing that there areother matrixes not considered that could improve the predictive strength of the model. This research is therefore a buildup along this research line. This work is set to consider more than two independent variables in regression equations so as to recommend an improved contractor selection model that can predict the lowest bid more accurately in competitive bidding. In doing that therefore:

1. Regression models, two of which have three independent variables and one with four were developed.
2. The models were compared with each other and with similar previous models in the view of recommending a more robust one that can better predict the lowest responsible bid in a competitive bidding system.

Identifying the lowest responsive responsible bid at an early stage of competitive bidding will reduce the burden and cumbersome nature of bid analyses, yet offer opportunity to identify a more reliable bids from bidders. Awarding contracts to the lowest responsive responsible offer will contribute immensely to smooth execution for a successful completion of construction projects.

LITERATURE

Factors affecting estimated figures and bid selection

Estimates are usually the bases for lowest bid selection in competitive bidding. Thereare factors that affect contractor's company estimated figure, andthere are those that affect the bid figure (figure submitted as offer to the client).The company estimated figure is simply the amount arrived at by the estimator as the real figure that will complete a proposed project under given conditions in a construction firm. Researches like Coningam (2017) have documented that the amount of information available, work complexity, risks factors, location of the job, availability of labour and material areamong the factors that determine such estimates. These factors guide the estimator in arriving at the actual cost of executing a proposed project which can be referred to as company's estimate. On the other hand, the bid figure is the final amount the contractor agrees to submit to the client in competition which could differ from the company estimate. There are factors affecting this amount offered by contractor's firm to the clientwhich invariably affect the chances of the contractor winning a competition. Four main factors identified are as follows:

a. Consultant's estimate: The more the consultant's estimate, the more the general bid prices of all the contractors. The consultant's estimate follows after the nature, characteristics and risk profile of the proposed project, likewise the bid figures offered. The consultant's estimate is often used to determine which contractor wins the contract in bidding (Oladokun *et al.*, 2010). As such, given the same information, the bidder is mindful of the amount the consultant will arrive atand use as bases of judging all bids submissions. In competitive bidding (Kim and Skibniewski, 2020), the consultant can annul all submissions if found that the bids are not within acceptable limit. The contractor therefore targets a consultant's position that can guarantee winning a contract with profit.

b. Number of competitors: this refers to the number of contractors invited by the client to compete for award of a proposed job. Various strategies have been developed for contractors to outsmart other competitors during bidding. Studieshave also shown that the more the number of contractors invited to bid for a particular project the more the likelihood of getting a lower offer (Carr, 2005). Researches have indicated the kind of factors most important and those less important in contractor's bidding strategy (Prajapati, Pitroda and Bhavasar, 2015). One of the strategy to outsmart other competitors, a contractor submits bid lower than others including the consultant's estimate. There are instances that the contractor lowers a bid figure to an unrealistic level just to win the contract. In a lowest bid system, such contractors can still win the contract but most often with associated challenges during contract implementation (Khan & Khan, 2015).

c. Amount of error: error in estimates come in diverse forms. For example, there is arithmetic error, error of omissions and commissions, error in transfer of figures during bill preparation, etc. The underlying issue here is that error can either add to the bid figure or reduce it. In most cases, it offsets the winning strategy of the bidder, making the offer either too low or too high unlike whatthe bidder targeted. Error has therefore been seen as affecting the chances of winning contracts.

d. Average bids: researchers have recommended the use of the average of all the bids to select a winner in construction competitive bidding system. The justification of the recommendation lies on the argument that it represents what the entire group of bidders believe is fair. Sammoura (2010) asserted that, it that it is what the group of bidders believes to be the fair value of the work and should form the bases of the selection process. Under this system, bids above and below the average could be judged unrealistic. Therefore, with the consultant's estimate and number of contractors invited to bid, after return of offers, the errors in each offer is assessed and then the average of the entire bid figures is computed.

Therefore, Carr ((2005) used the consultant's estimate and number of bids to develop a model to predict the lowest bid a contractor shouldreasonable offer. This research premises that among these four variables, one or a combination should forma better means ofdetermination of the lowest responsive responsibly bid among the competitors which is the subject of enquiry.

Contractor selection

The selection of the right contractor for a construction job is still a challenging task in the competitive bidding system (Gandu *et al.,* 2020). The promotion of efficiency relates to the selection of the bidder with the lowest price among others so as to achieve best "value for money" on behalf of the investor (OECD, 2011). The lowest bid is still given high considerations and favoured by public clients in the award of contracts. For example, the lowest bid is extensively favoured for award of public works contracts in the US (Shrestha & Pradhananga, 2010), India (Kumar & Raj, 2020) and Pakistan (Khan & Khan, 2015). By implication, contractors that submit the lowest bid during competition usually wins the contract. Purportedly, the lowest bid has not often performed satisfactorily in meeting up with the objectives of the bidding process (Bajaber & Taha, 2012). Shrestha & Pradhananga (2010) demonstrated the impact of competitive bidding on a bid price of the projects and found that, the greater the number of bidders competing in a bidding process, the lower the likelihood bidders will offer. Khan & Khan (2015) observed that unrealistically low bids have won contracts during competitive bidding in Pakistan with consequences of impediments to construction contracts success. Also, the impact of the lowest bid price on the final construction cost of projects was found as not always resulting in a low construction cost (Shrestha & Pradhananga, 2010). There was a proposed statistical procedure based on average bid price to eliminate the unrealistically low bids in competitive bidding (Hiyassat, 2000).

Perturbed by large number of defaulted or failed projects and large number of disputes attributed to contractors during construction contract implementation process, Bajaber and Taha (2012) investigated the way contractors are selected in Saudi Arabia. It was the submission of the researchers that with proper selection of the contractor, the anomalies will be reduced to a greater extent. The research found among others that the industry relies so much on lowest price as criterion for award of contracts which caused the anomalies. The practice guarantee incompetent lowest bid contractors becoming successful during bidding; and such contractors were behind defaults and failures during the contract execution processes. Mahmood *et al.,* (2010) believe that it is natural that lowest bids contain unreasonable low rates as strategy of winning competitions, and that this has failed to deliver projects within required cost, time, scope and quality demand. In Pakistan, the award of construction projects also favours the lowest bidder most often. The Pakistani public sector relies so much on lowest bid system in construction contracts award the essence of which is to obtain the least cost of construction projects (Khan & Khan, 2015). The effect of this low bid awarding system in public construction projects and also, the general performance of the lowest bid system during construction contract execution in Pakistan was therefore investigated (Khan & Khan, 2015). Ina questionnaire survey, Khan & Khan (2015) compared five other contractor selection systems with the lowest bid approach using 10 contractor's performance parameters. The lowest bid system was found to be a poor system in project delivery in terms of cost, time and quality demand. The research found over 50% of the projects studied which were awarded based on the LBS overran their budgets and ended up with higher cost consequences. Respondents opined that the situation will improve if the lowest bid system of award is avoided. Kim & Skibniewski (2020) were in the view that the bids rejected in favour of the lowest could contain more important information beneficial to the project success even better than the lowest bid favoured. Kim & Skibniewski (2020) argued that the possibility exists where some risks were discovered which increased the bids above the lowest one favoured. Kim & Skibniewski (2020) then established that project that experience wider bid variation during competitive bidding tagged as risky projects, is more likely to end up with higher construction cost when compared to those with narrower bids variations.

The literature therefore established among others, how bidding can affect success of construction contract execution including factors influencing bidding chances.

METHODOLOGY

This paper is a follow-up to the works done by Carr (2005) and Gandu*et al.* (2020).Therefore, following Carr (2005)'s model, Gandu*et al.* (2020) who were drawn to its weaknesses complemented the research trajectory. Gandu*et al.*(2020) then established seven different regression equations from four identified factors that can predict the lowest bid. The predictive strength of the seven equations were compared with that of Carr (2005) but concluded that Carr (2005)'s model, equation 6 in Table 1with NB and CE as independent variables was more feasible. Table 1 indicates the selection of variables used by Gandu*et al. (*2020).

Table 1: Independent variables in each equation

Equations	Independent variables			
	CE	ACB	APE	NB
Equation 1	✓			
Equation 2		✓		
Equation 3			✓	
Equation 4				✓
Equation 5	✓	✓		
Equation 6	✓			✓
Equation 7		✓		✓

Source: Gandu *et al.,* 2020

Key

CE Consultant's Estimate, independent variable (x1)
ACB Average Corrected Bid, independent variable (x2)
APE Average Percentage Error, independent variable (x3)
NB Number of Bids, independent variable (x4)

However, one key finding in Gandu *et al.* (2020)'s research is that the combination of different variables affected the robustness of the equations. There was mutual effects among variables when combined in different equations. Variables exhibited different degrees of influence on lowest bid prediction in different equations. Therefore, the possibility that other robust models exist when more variables are combined in the same equation was established.

Data for the analyses consist of extractions of the required variables, the NB, CE, ACB and APE from bidding reports of a set of hydro engineering water projects that were performed between 2015 and 2017 and supplied by two client organisations- The Sokoto Rima River Basin and Rural Development Authority, and The Hadejia Jamare River Basin. Both organisations that supplied the data are responsible in public water supply projects representing the North Eastern and North Western regions of

Nigeria. Thirty six (36) completed projects of diverse magnitudes involving 220 bids with diverse level of competition was used.

Two regression equations with a matrix of three variables and one with a matrix of four were developed and then compared with the findings reported by Carr (2005) and Ganduet *al.* (2020). The first equation combined the variables of CE, ACB and APE, while the second one has NB, ACB and APE. The combination pattern of three and four variables is shown in Table 2. The equations derived from numbers 1 and 2 were first compared and the best among them compared with equation from number 3 and then the earlier equation recommended by Gandu et al. (2020).

Table 2: Independent variables in each equation

Numbers	Independent variables			
	CE	ACB	APE	NB
1	✓	✓	✓	
2		✓	✓	✓
3	✓	✓	✓	✓

Key

CE Consultant's Estimate (independent variable x1)
ACB Average Corrected Bid (independent variable x2)
APE Average Percentage Error (independent variable x3)
NB Number of Bids (independent variable x4)

RESULTS

Table 3 reports the results of the summary of the regression statistics of the equations in question. The firstvalues generated in this work are for the equation consisting of variables recommended by Ganduet *al.*(2020) while equations 2 to 4 are values for the new equationsgenerated.

EQUATION	INTERCEPT	SLOPE	R SQUARE	STD. ERROR	SST	SSR	SSE	P-REGRESSION	P-VALUE
1 -CE	8754554.303	0.814	0.954	5640825.187	2.296E+16	2.191E+16	1.050E+15	0.000	0.000
-NB		-1680451.124						0.000	
2 -CE	-1786282.585	0.671	0.929	7150065.567	2.296E+16	2.133E+16	1.636E+15	0.000	0.000
-ACB		0.159						0.209	
=APE		12704627.71						0.614	
3 -ACB	10688477.016	0.828	0.880	8868127.967	2.296E+16	2.044E+16	2.517E+15	0.000	0.000
-APE		106872026.838						0.000	
-NB		-1817926.592						0.003	
4 -CE	8447902.056	0.0653	0.959	5511943.307	2.296E+16	2.202E+16	9.418E+14	0.000	0.000
-ACB		0.0 180						0.069	
-APE		23203112.83						0.239	
-NB		-1712754.330						0.000	

Y= 87545544.303+0.814CE-1680451.124NB -------------1
Y= -1786282.585 + 0.159ACB+ 0,671CE+ 12704627.705APE -------------2
Y = 10688477.016 + 0.828ACB + 106873026.838APE – 1817926.582NB ------------3
Y=8447902.056 + 0.0653CE + 0.018ACB + 23203112.83APE - 1712754.330NB --4

Where Y is the dependent variable (lowest bid), while CE, NB, ACB and APE are independent variables in the equations.

DISCUSSIONS

Table 3 above presents the summary of regression statistics of four equations (eqn. 1-4). The equations have different matrixes of factors that influence the lowest bid in a competitive bidding system. The equations are compared to ascertain the onewith the best tendency to predicting more correctly the lowest responsive responsible bid at the earliest possible time in a bidding process. Three new equations (2-4) were generated and compared with Gandu*et al.* (2020)'s findings reported in equation 1. Gandu et al. (2020) recommended the consultant's estimate (CE) and number of bids (see equation 1) as the best predictor of lowest bid in a bidding system similar to Carr (2005). That analyses of the set of equations by Gandu*et al.* (2020) revealed a case where some variables impacting on the robustness of the equations, especially where the matrixes of two variables were used. The research did not set to combine more variables.As such, the need to investigate further by combining three variables and the four in an equation becomes an issue of research concern which is addressed herein.

Comparing the equations 2 and 3 with three variables in Table 3, the p-values of equations 2 and 3 are both 0.000 which is less than 0.05 level of significance. It indicates that the relationship between the dependent and independent variables in each equation is of significant strength. It means both equations can be used in predicting the lowest bid with significant accuracy. The next question is that, when the independent variables change, to what extent does the dependent variable react or change? The Square r values in the table measures the ratio of change in the dependent variable by virtue of the changes in the independent variables, which therefore measures the level of dependency between them. Equation 2 has three independent variables which are CE, ACB and APE, and has a value of square r as 0.929 for the equation. This interprets as 92.9% level of dependency between the dependent and the independent variables. In other words, 92.9% of the change in the dependable variable (Y) is as a result of the change in the independent variables (Xi). Equation 3 shows square r value to be 0.88 or 88% level of dependency and this is less than that of equation 2. It suggests that equation 2 is a better predictor of the lowest responsive bid than equation 3. The sum of squares residue SSR is the measure of the amount of changes in the dependable variable that can be explained. It is said to be explained because the changes are due to the relationship with the independent variables otherwise, other factors outside the relationship could be the cause of the changes. Equation 2 has SSR value as 2.133E+16, i.e. the amount of changes that can be explained and 1.636E+15 (SSE) which cannot. The amount of changes that can be explained is far greater than that which cannot, which also connotes a strong relationship. Comparing equation 2 to equation 3(equation 3 having the SSR as 2.044E+16 and SSE as 2.517E+15) the relationship between x and y in 2 is stronger than in 3.Thereis more external influence (SSE) in 3 (2.517E+15) than in 2 (1.636E+15). In other words, a greater amount of changes in 3 cannot be explained as compared to 2. It can be concluded from the analyses that equation 2 is a better predictor compared to 3.

Since we are interested in the best equation, at this level, we eliminate equation 3 to be left with three equations (1, 2 and 4) driven. The first equation (1) has been found to be better by previous researchers and the second (2) established to be better than the other from the analyses of the regression statistics. The two are then compared with equation 4. Equation 1 has two variables, equation 2 has three variables and equation 4 has all the four variables believed to influence the lowest bid combined. The key issue is to find out which among the three equations best predicts the lowest bid in competitive bidding system.

The p-value of equations 1, 2 and 4 are both 0.000. The values are both less than 0.05 level of significance. It indicates that we reject the no significance hypothesis and accept that there is significant relationship between x and y for both equations. By implication, the dependency of the independent variables on the dependent variables in all the equations is significant. It is established here that the equations are therefore good predictors of the lowest bid. Furthermore, we consider the value of the square r of all the equations which estimates the ratio of influence of the independent variables on the dependent variables. In other words, when the independent variables x_i change, to what extent does the dependent variable y change? Equation 1 has value of square r as 0.954, equation 2 has 0.929 and equation 4 is 0.959. It means the level of dependency of y on x for the equations are 95.4%, 92.9% and 95.9% respectively. Equation 4 has stronger degree of dependency and is therefore a better predictor by virtue of this result followed by equation 1 and then 2. Also, the explained variable SSR in the equations are 2.191E+16, 2.133E+16 and 2.202E+16 respectively. Again equation 4 has higher value of SSR which proves that there is a higher degree of the changes that can be explained which shows that the influence on y as a result of the relationship with x is higher, followed by equation 1 and then 2. Similarly, the external influence in the equations that cannot be explained SSE are 1.050E+15, 1.636E+15 and 9.418E+14 respectively which depicts less value in equation 4. Thus, it still confirms equation 4 as the best and followed by equation 1 also and then 2.

The standard error, is the measure of deviation of the individual values Yi from the mean of Yi. The table shows that equation 1, 2 and 4 have standard error values as 5640825.167, 7150065.567 and 5511943.307 respectively. Equation 4 has a lower error value which means that the individual values of Yi comparatively deviates less from the mean of Yi. Therefore, the likelihood of error if the equation is used to predict Y is less. This is therefore a better model and followed by equation 1 for having the lower standard errors compared to equation 2. The conclusion under this section is that the best equations to predict the lowest bid among many bidders in an order of priority are equations 4, 1 and 2.

However, looking at equation 1 which has two variables consisting of CE and NB, and both variables are contributing significantly in predicting the lowest bid as their p-regressions values (both 0.000) are less than 0.05 it suggests a good case. Equation 2 on the other hand has three variables which are, CE, ACB and APE. The equation denotes that two out of the three variables, ACB and APE are not contributing significantly in the prediction nature of the equation as the p-regression of both variables are 0.209 and 0.614 for ACB and APE respectively, and each above 0.05. Equation 2 therefore depends heavily on the CE in the prediction effort since ACB and APE are not contributing much. Equation 4 has all the four variables as the independent variables which was also adjudged as the best equation. However, the p-regressions indicate that two variables, ACB and APE are not contributing significantly in the equation also as the p-regressions are greater than 0.05 also, the values being 0.059 and 0.259 respectively. By implication, only the CE and the NB are contributing significantly with p-regressions as 0.000 each which is less than 0.05. It shows that equation 4 depends heavily on the CE and NB which are the same variables contained in equation 1 which can be considered a more feasible equation. Furthermore, equation 1 which depends on CE and NB has the capacity to predict the lowest bid earlier in the bidding process because it can be achieved as soon as the consultant's estimate is ready. By the time the consultant prepares an estimate, the client needs only to decide on the number of bidders in a bidding competition to determine the expected lowest responsive bid. In equation 4, even though being more robust, must wait till the return of bids from contractors and the labour of assessing the errors and average corrected bid before the lowest responsive bid can be ascertained mars the advantage.

CONCLUSION

This research set out to derive a model that can be used to predict the lowest responsive bid in a construction competitive bidding system. Four variables were identified as having some degree of influence in arriving at the lowest bid offered by the contractor in competitive bidding. The four variables were used to derive a set of regression models using different matrixes. The equations driven were then compared. It was discovered that:

1. Three equations were robust in predicting the lowest responsive bid.
2. There is mutual influence between variables combined in an equation which affect the robustness of an equation depending on the variables combined.
3. The regression model that combines the four variables as independent variables was the most robust with 95.9% dependency followed by the one with two variables (CE and NB) with 95.4%.
4. Error and the average of bidders exert insignificant influence in predicting lowest bid in competitive bidding. In contrast, the number of bids and the consultant's estimate exert significantly.
5. Predictingthe lowest bid depends significantly on two variables which are CE and NB. Even though the contribution of error and average bids in predicting the lowest bid is insignificant in the equations derived, the strength of the equation with both variables included was improved compared to when they were excluded.
6. The lowest bid is directly proportional to the consultant's estimate but inversely proportional to the number of bids solicited. In other words, the higher the consultant's estimate the higher the lowest bid but the more the number of competitors the less the lowest offer, vice versa

RECOMMENDATION

Equation 4 is the most robust predictor of the lowest bid in competitive bidding and is recommended in this work.

Y =8447902.056 + 0.0653CE + 0.018ACB + 23203112.83APE - 1712754.330NB --4

However, it can only be used under the condition that bids have been returned and analysed such that the error level of each and the average of all the bids submitted obtained. This limits the prediction in this case to functions just to ascertain the optimum offer for award. Where there is the need for earlier prediction of the lowest bid even before contractors are invited, and if there's need to avoid the laborious bid analyses, then equation 1 is recommended as the optimum predictor of the lowest bid in competitive bidding.

Y = 87545544.303 + 0.814CE - 1680451.124NB ------------1

Equation 1 has CE and NB as the independent variables. This finding further establish the earlier research works done by Carr (2005) and Gandu*et al.* (2020) who recommended the use of CE and NB to predict the lowest responsive bid in a similar study. However, a more scientific justification has been established on the choice of the two independent variables.

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