Development of Sensitivity-Based Model for Flexural Failure of Singly Reinforced Concrete Slabs Based on BS 8110:1997

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Abstract: This research presents mathematical models for checking the effect of variation in key designed parameters on the structural collapse of singly reinforced concrete solid slabs in buildings due to flexural failure based on British Standard (BS) 8110, 1997. The increasing complexity of construction process requires very high level of engineering and management skills to combat the structural collapses widely experienced globally. Most of the collapses were adjudged to be due to improper management arising from variations in structural key design parameters during construction, and this call for mathematical models to check the effect of variation in key design parameters on the structural collapse. The key design parameters considered in this research are; characteristic strength of reinforcement, grade of concrete, diameter and spacing of tension reinforcement, effective depth of tension reinforcement, applied moment. Sensitivity analysis was applied to study the effect of variation in the key parameters on the moment capacity. The results of sensitivity analysis were utilized in regression analysis to develop simplified equations for estimating the moment capacity of the slab. Computer programme was developed based on BS 8110, 1997 standard using Java to verify the model. Flexure safety factor was also checked based on BS 8110, 1997 requirements. Forty five numerical examples were taken to validate the model with the developed computer programme at 5% significance level using Chi-squared as an instrument for sensitivity-based model for flexural failure of singly reinforced concrete slab. The results show that the model is adequate at 5% significance level for checking flexural failure of singly reinforced concrete slab at construction stage based on BS 8110, 1997. It was recommended that the construction practitioners should consider the diverse effect of change in key deigned parameters during construction, otherwise the developed model should be strictly considered for quick safety check especially deflection safety of a solid slab during construction.

Keywords: Flexural failure; Sensitivity-based model; Singly reinforced concrete slab.

Introduction

In order to provide a structure that correspond to the requirements and to the assumption made in the design, appropriate quality engineering management measures should be in place such as control at the stage of design, construction, use and maintenance. Since the aim of design is to ensure that with an acceptable level of probability a structure will, during its intended designed working life, perform satisfactory. Also with an appropriate degree of reliability and in an economical way, a structure should among others sustain all loads and deformation likely to occur during construction and use; remain fit for the purpose of its intended use (BS 8110 1997; Mosley *et al.*, 2007).

Structural use of concrete code of practice for design and construction is mostly carried out based on British Standards (BS) 8110, 1997 or Eurocode (EC) 2, 2004. However, whether the design has been based on British Standard or Eurocode, structural collapses are world widely experienced and this has been of great concern to structural designers and construction managers (Cowan, 1989; Folagbade, 1997; Roddis, 1993; Bamisele, 2000; Akinpelu, 2002; Folagbade, 1997). Most of the collapses were adjudged and traceable to many factors amongst which is improper management arising from variations in structural key design parameters during construction, and this calls for development of mathematical models as a tool to check the possible effect of variation in key designed parameters on the structural elements.

The occurrence of building collapses worldwide including Nigeria has been of great concern and this pose serious challenges to all the stakeholders in the construction industry – building construction, developers, landlords and the end users and so on. In attempt to find lasting solution to tackle this challenges, enormous researches examine some of the major causes of building collapses and tries to proffer remedial measures that may curb the menace (Ali, 2012; Atume, 2012; Chendo and Obi, 2015; Matawal, 2012; NBBRI, 2011a, b, c, 2012; Wardhana and Hadipppriono, 2003; Saleu, 1996; Taiwo and Afolani, 2011). In the same vein, possible control has been suggested by Adebayo (2000, 2005, 2006); Bamisele (2000); Arayela and Adam (2001); Ogunsemi, (2002); Yusuf (2002); Ayinuola and Olalusi (2004); Ezeage (2007); Ede (2010a, 2010b, 2011) and yet there is no significant sign of curbing the menace.

In a related development, sensitivity analysis of the effect of variation in key designed parameters on the resistance of reinforced concrete members has been carried out by many researchers (Lind, 1983; Nowak and Tabsh 1989; Hamby, 1994; Dias, 1996; Oloyede, *et al*, 2010; Oyenuga, 2011). Despite these researches, development of sensitivity-based regression model for checking key designed parameters in structural collapses of reinforced concrete member under flexure based on BS 8110, (1997) has not been given much attention. Similarly, sensitivity-based model as a construction engineering and management tool for estimating the influence of variation on the safety of any reinforced concrete member including slab during construction is yet to be developed. Although, detailed structural redesign could be used to achieve this during construction, significant expertise effort is required. The increasing complexity of construction process requires very high level of engineering and management skills to combat the structural collapses often experienced worldwide (Montgonery and Runger, 2003).

There is always variation in the key parameters of structural elements such as; characteristic strength of reinforcement and concrete, grade of concrete, diameter and spacing of tension reinforcement, effective depth of tension reinforcement, and design span of slab at the construction stage by the construction practitioners as against the designed (Fakere *et al*., 2012; Ike, 2012). Key designed parameters of the structural elements are altered either to reduce the cost and maximizing the profit margin or unavailability of some materials as specified in the design or introduction of hollow members like pipes, which usually decrease the effective working area of the concrete (Saleu 1996; Ogunsemi 2002). The need for the development of explicit model to easily check the effect of such variations in key design parameters is enormous and of great importance to avert the possible structural collapse. Contemporaneously, the use of explicit model will ensure that structural members altered meet the minimum safety criterion and thus reduce the risk of structural failure of singly reinforced concrete slabs.

Consequently, this paper presents sensitivity-based regression model for checking the effect of variations of key designed parameters on the flexural collapse of singly reinforced concrete solid slab of building based on BS 8110, 1997 using partial differential sensitivity analysis and regression. The key designed parameters considered in this research are; characteristic strength of reinforcement and concrete, grade of concrete, diameter and spacing of tension reinforcement, effective depth of tension reinforcement, design span of slab; fixed end condition of slab and ultimate design load and applied moment.

Conversely, the aim of the research is to however develop a sensitivity-based model for checking safety of reinforced concrete members during construction due to possible variations in the key designed parameters. Objectively, simplified mathematical model and computer programme were developed based on BS 8110, 1997 standard using Java to verify the model, and forty five numerical examples were taken to validate the model with the developed computer programme at 5% significance level using Chi-squared as an instrument for sensitivity-based model for flexural failure of singly reinforced concrete slab.

Materials and Methods

The sensitivity-based model for checking key parameters in structural collapse of singly reinforced concrete slab under flexure encompasses the: formulation of theoretical safety equation ; moment capacity and effective depth of tension reinforcement; sensitivity and regression analysis of singly reinforced concrete solid slab under construction. Similarly, develop computer programme to verify and validate the model at 5% significance level using Chi-squared based on BS 8110, 1997.

Formulation of Safety Equation of Slab under Flexure

The safety of structural members depends on its resistance and loads effects which can be expressed in term of limit state function, g (BS 8110, 1997; Oyenuga, 2011; Mohammed, 2014)

According to Limit state principle, the safety margin g, of a structural member is given by:

$$g = g_c - g_a \qquad (1)$$

where; g is the safety margin, g_c is the resistance and g_a is applied resultant load effects on the member.

Dividing the right hand-side of equation (1) by g_a, to set the safety margin, g in % yield equation (2)

$$\frac{g_c}{g_a} = g + 1 \qquad (2)$$

The factor of safety λ λ is defined as:

$$\lambda = 1 + g \qquad (3)$$

Replacing $1 + g$ in equation (2) yields equation (4) which is the factor of safety against failure of slab in this study.

$$\lambda = \frac{g_c}{g_a} > 1.00 \qquad (4)$$

Equation (4) is a limit state equation which defined the safety region. The value of $\lambda < 1.00$, defined the failure region, and $\lambda = 1.00 \lambda = 1.00$ defines the boundary between the safety and failure regions. This implies that if, $\lambda > 1.00$, the slab is safe otherwise the slab has failed.

According to BS 8110 (1997), when the depth of slab is less than or equal to 200mm, the major flexure failure of the slab is considered to be due to moment capacity. From equation (4), the flexural safety factor of a slab is thus defined as:

$$\lambda = \frac{M_c}{M_a} \Rightarrow 1, \qquad (5)$$

where; M_c is the moment capacity, M_a is applied moment due factor loads, λ_f flexural safety factor

Moment Capacity Formula

A reinforced concrete member with yield strength of reinforcement f_y, and compressive strength of concrete f_{cu}, the design moment capacity results from the internal compressive force, F_{cc} and internal tensile force T, separated by the lever arm, Z. For a singly reinforced concrete slab with rectangular section, see Fig. 1.

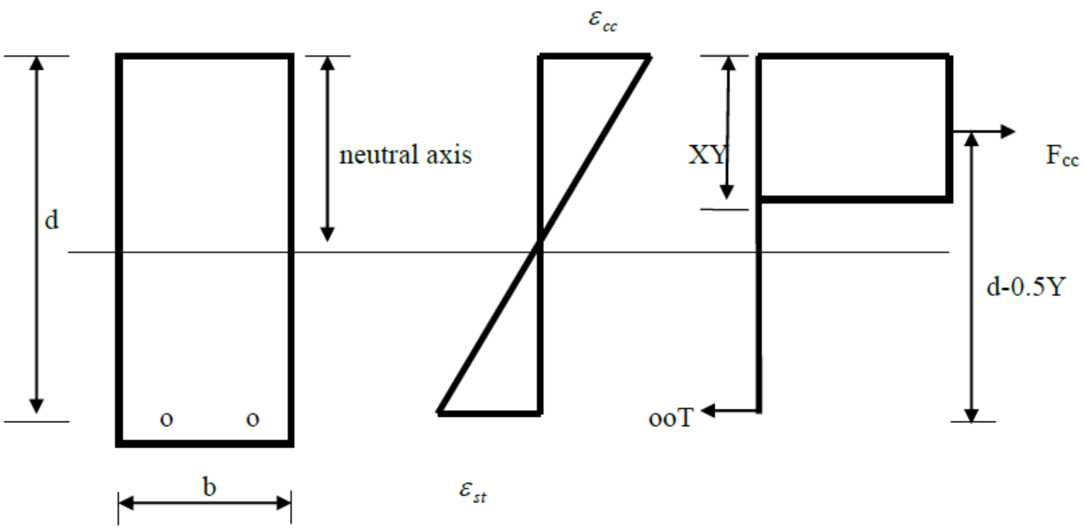

Fig. 1: Singly reinforced concrete section with rectangular stress block

In accordance to BS8110, 1997;

T = stress × area of action $= 0.95 f_y \times A_{prov}$

F_{cc} = stress × area of action $= 0.45 f_{cu} \times bY$

where; A_{prov} is the area of tension reinforced provided, b is the width of the slab and Y is the depth of stress block.

Having, $T = F_{cc}$, from equilibrium as in BS8110, 1997 obtained T to be

$$0.95 f_y A_{prov} = 0.45 f_{cu} bY \qquad (6)$$

From equation (6) the depth of stress block is given by:

$$Y = \frac{0.95 f_y A_{prov}}{0.45 f_{cu} b} \qquad (7)$$

Taking moment about the compressive force, F_{com} in the concrete, the moment capacity, M_c of a slab is given by BS 8110, 1997 as

$$M_c = 0.95 f_y A_{prov}(d - 0.5Y) \quad \ldots \qquad (8)$$

Replacing Y from equation (8) and simplifying yields the moment capacity equation, M_c of a singly reinforced concrete rectangular section (BS8110, 1997):

$$M_c = \left[746.128\frac{\phi^2 f_y}{S_t}\left(d - 0.829\frac{\phi^2 f_y}{S_t f_{cu}}\right)\right] \times 10^{-6}\ \text{kNm} \qquad (9$$

where, f_y - the characteristic strength of steel, d is the effective depth of tension reinforcement, f_{cu} - the characteristic strength of concrete, ϕ - the diameter of the tension reinforcement bar, and S_t - the centre to centre spacing between tension reinforcement

Differential Sensitivity Analysis

In order to conduct differential sensitivity analysis on the moment capacity, M_c, reference data of key parameters of slab were used and the data were as presented in Table 2.1.

Table 2.1: Reference Value of Key Parameters for Moment Capacity

S/No	Parameter (y_{0i})	Reference Value
1	Characteristic strength of steel, f_y or f_{yk}	500N/mm^2
2	Diameter of tension steel bar, ϕ	12mm
3	Spacing of tension steel bars, S_t	300mm c/c
4	Effective depth of tension steel bar, d_{pr}	150mm
5	Characteristic strength of concrete, f_{cu} or f_{ck}	30 N/mm^2

The reference data of the key parameters in moment capacity were varied in turn of $0\%, 1\%, 2\%, \ldots, 50\%$, and effect of variations on moment capacity and contribution of each parameter on moment capacity were respectively obtained.

The differential sensitivity coefficient of the moment capacity parameters of slab provided by BS 8110, 1997 is given as

$$\delta M_{cyi} = \frac{\partial M_c}{\partial y_i}\delta y_i \qquad (10)$$

where; y_i is the moment capacity parameters of a slab, δy_i - the change in y_i, during construction and is defined as:

$$\delta y_i = 0.01w \times y_i \qquad (11)$$

where; w is the % change in y_i during construction and is assigned the values of $0\%, 1\%, 2\%, \ldots, 50\%$, in this research.

The contribution of each parameter to moment capacity, M_{cy_i}, is given by:

$$M_{cy_i} = \frac{\delta M_{cyi}}{\sum_{i=1}^{n}\delta M_{cy_i}} M_c \qquad (12)$$

Multiple Linear Regression Analysis

The sensitivity data were transformed and used in multiple linear regression analysis to obtain equation for estimating moment capacity, M_c:

Let μ be the ratio of y_i to y_{0i}, then

$$\mu_i = \frac{y_i}{y_{oi}} \qquad (13)$$

where y_i is the key designed parameter that affect the moment capacity of a slab provided and y_{oi} is the reference value of key designed parameters.

Assuming that the forth root of moment capacity, $\sqrt[4]{M_{cyi}}$ in accordance to BS

8110, 1997 has a linear relationship with, μ_i and is given by:

$$\sqrt[4]{M_c} = \left(\beta_o + \beta_{fy}\left(\frac{fy}{500}\right) + \beta_\phi\left(\frac{\phi}{12}\right) + \beta_{S_t}\left(\frac{s_t}{300}\right) + \beta_d\left(\frac{d_{pr}}{150}\right) + \beta_{f_{CU}}\left(\frac{f_{cu}}{30}\right) + e_i \right)$$ or

$$M_c = \left(\beta_o + \beta_{fy}\left(\frac{f_y}{500}\right) + \beta_\Diamond\left(\frac{\phi}{12}\right) + \beta_{s_t}\left(\frac{s_t}{300}\right) + \beta_d\left(\frac{d_{pr}}{150}\right) + \beta_{f_{cu}}\left(\frac{f_{cu}}{30}\right) + e_i \right)^4$$

(14)

where β_o and $\beta_{f_y}, \beta_\phi, \beta_{S_t}, \beta_d, \beta_{f_{cu}}$ are the intercept and slopes and are called regression coefficients, e_i is the possible error term and is assume to be uniformly distributed with mean zero and variance, σ^2.

Substitute equation (14) in (5) yields equation (15)

$$\lambda_f = \frac{\left(\beta_o + \beta_{fy}\left(\frac{f_y}{500}\right) + \beta_\phi\left(\frac{\phi}{12}\right) + \beta_{s_t}\left(\frac{s_t}{300}\right) + \beta_d\left(\frac{d_{pr}}{150}\right) + \beta_{f_{cu}}\left(\frac{f_{cu}}{30}\right) + e_i \right)^4}{M_a} \qquad (15)$$

where M_a the applied resultant moment is given by, $M_a = \alpha F L_x^2$, α is the moment coefficient of a slab, L is the design span of the slab, F is the design ultimate load on a slab, d_{pr} is the effective depth of tension reinforcement provided, f_y is the characteristic strength of steel, f_{cu} is the characteristic strength of concrete, ϕ is the diameter of the tension reinforcement, S_t is the centre to centre spacing between tension reinforcement bars. Equation (15) is the equation for checking key parameters in the flexural collapse of singly reinforced concrete solid slab in buildings during construction in this study.

Development of Computer Programme

The computer programme was developed to verify the model using JAVA programming language, developed in net beans integrated development environment (IDE) 7.0.

The programme slab efficiency, S_{coef} implemented one-way, two-way and cantilever slabs. One panel was checked at a time. The programme is divided into segments where all the various input and output are defined. The applied moment coefficient for two-way slab was obtained from the code while applied moment for one-way slab was generated using Clyperon's three moment equation. The programme checked for flexural failure of each slab types and sub-types and draw visual inference on whether the slab checked was safe or not and the results were saved and printed. The flow chart depicting the computer programme is as presented in Fig. 2.

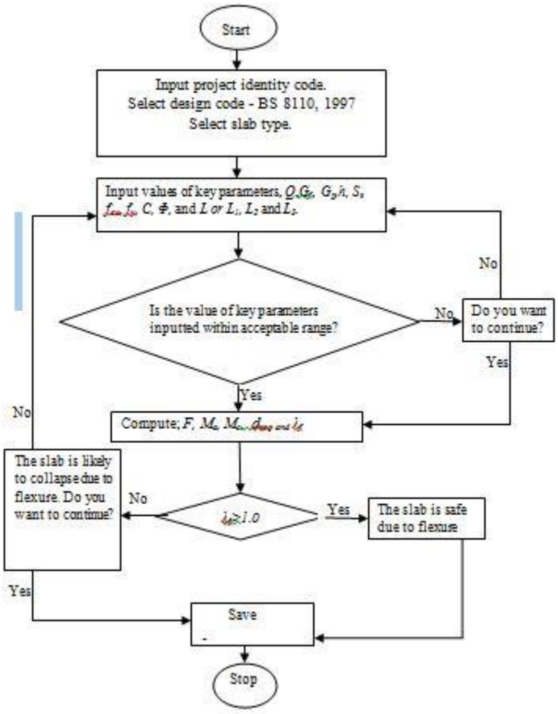

Fig. 2: The flow chart for checking flexural failure of singly reinforced concrete solid slab in buildings during construction based on BS 8110 (1997).

Model Validation

Forty-Five numerical examples were solved using the obtained model and the computer programme and the results were compared at 5% significance level that the variance of the factor of safety predicted does not exceeded 0.05 using Chi-square, (X_0^2 less than $X_{0.05,44}^2$).

Results and Discussions

The relevant data from the sensitivity analysis were utilized in the regression analysis and the data used for regression analysis is as presented in appendix A. The summary of results of the regression analysis is presented in Table 3.1

Table 3.1: Multiple regression for effects of key parameters on moment capacity

Regression: Forth root of moment capacity against variations in key parameters

$Observation = 51$, $Coefficient\ of\ determination, R^2 = 0.9998$, $Adjusted\ R^2 = 0.9994$, $Standard\ error = 0.004$, $\beta_0 = 0.485$, $\beta_{f_y} = 0.599$, $\beta_\phi = 1.118$, $\beta_{S_t} = -0.599$, $\beta_d = 0.634$, $\beta_{f_{cu}} = 0.037$

From the solution of regression analysis the equation for estimating moment capacity of singly reinforced concrete slab is given by:

$$\sqrt[4]{M_c} = 0.485 + 0.599\left(\frac{f_y}{500}\right) + 1.118\left(\frac{\phi}{12}\right) - 0.599\left(\frac{S_t}{300}\right) + 0.634\left(\frac{d}{150}\right) + 0.37\left(\frac{f_{cu}}{30}\right) + 0.004$$

Hence the equation for checking key parameters in the flexural collapse of singly reinforced concrete solid slab during construction in this study becomes:

$$\lambda_f = \frac{\left(0.485 + 0.599\left(\frac{f_y}{500}\right) + 1.118\left(\frac{\phi}{12}\right) - 0.599\left(\frac{s_t}{300}\right) + 0.634\left(\frac{d_{pr}}{150}\right) + 0.37\left(\frac{f_{cu}}{30}\right) + 0.004\right)^4}{M_a} \succ 1.00$$

Model Validation

The results of the comparison of flexural collapse factor using the obtained model and formula in BS 8110, 1997 at 5% significance level that the variance of the flexural collapse factor predicted does not exceed 0.05 using *Chi*-square is as presented in Table 3.2.

Table 3.2: Comparison of Flexural Safety Factor based on BS8110, 1997

S/N	Factor of Safety using Computer λ_c	Factor of Safety using Model λ_m	$\lambda_c - \lambda_m$	$(\lambda_c - \lambda_m)^2$
1	13.76	13.42	0.3373	0.1137
2	1.17	1.18	-0.0052	0.0000
3	4.62	4.44	0.1796	0.0323
4	6.24	6.38	-0.1384	0.0192
5	0.80	0.83	-0.0304	0.0009
6	2.03	1.98	0.0500	0.0025
7	3.87	4.00	-0.1266	0.0160
8	0.73	0.89	-0.1595	0.0254
9	3.43	3.27	0.1603	0.0257
10	0.76	0.81	-0.0571	0.0033
11	2.95	2.91	0.0427	0.0018
12	15.29	14.71	0.5822	0.3389
13	4.15	3.75	0.3943	0.1555
14	0.76	0.79	-0.0377	0.0014
15	1.83	1.91	-0.0740	0.0055
16	0.73	0.72	0.0102	0.0001
17	2.06	2.18	-0.1175	0.0138
18	0.82	0.84	-0.0211	0.0004
19	1.33	1.40	-0.0675	0.0046
20	2.26	2.26	0.0015	0.0000
21	2.86	2.67	0.1842	0.0339
22	5.78	4.94	0.8476	0.7184
23	3.31	3.34	-0.0282	0.0008
24	0.86	0.91	-0.0506	0.0026
25	3.51	3.62	-0.1151	0.0133
26	2.00	2.28	-0.2752	0.0757
27	1.16	1.17	-0.0149	0.0002
28	0.67	0.65	0.0189	0.0004
29	0.71	0.75	-0.0449	0.0020
30	1.29	1.34	-0.0566	0.0032
31	8.85	8.84	0.0103	0.0001
32	5.18	5.82	-0.6370	0.4058
33	0.91	0.94	-0.0305	0.0009
34	1.10	1.09	0.0095	0.0001
35	3.37	3.02	0.3524	0.1242

36	0.33	0.35	-0.0148	0.0002
37	0.63	0.66	-0.0363	0.0013
38	0.72	0.75	-0.0317	0.0010
39	0.56	0.60	-0.0352	0.0012
40	1.30	1.39	-0.0911	0.0083
41	1.79	1.86	-0.0676	0.0046
42	2.82	2.76	0.0571	0.0033
43	1.44	1.42	0.0218	0.0005
44	0.57	0.85	-0.2761	0.0762
45	0.92	0.97	-0.0522	0.0027

Variance, $S^2 = \frac{\Sigma(\lambda_c - \lambda_m)^2}{n-1} = 0.05095$

The calculated Chi-square, $X_0^2 = \frac{(n-1)S^2}{\sigma_0^2} = \frac{44(0.05095)}{0.05} = 44.84$

From the Chi-square Table, $X_{0.05,44}^2 = 60.30 > 44.84$ then we accept that the variance of the flexural safety factor predicted using the obtained model equation based on BS8110 (1997) has not exceeded 0.05. Effect of variations of key designed parameters on the moment capacity is demonstrated in Appendix A

Conclusions

From the results obtained the following conclusions are drawn:

1 Sensitivity-based model equation indicates that the effective depth, the diameter, the strength and spacing of tension reinforcement have a much greater influence on moment capacity than does the concrete strength.

2 The model is adequate at 5% significance level for checking the effect of variation in key parameters on the flexural collapse of singly reinforced concrete solid slabs of buildings.

3 Construction practitioners should be educated on the consequence of change in key designed parameters during construction and appropriate recommended standard code of conduct, building regulations and by-laws for the building industry should be strictly adhered.

4 There is need for engineers to develop similar model for other structural members in buildings for quick safety checks during construction.

5 The computer programme could be used for checking flexural failure of singly reinforced concrete slabs in buildings based on BS8110, 1997.

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Appendix A: Effect of Variations in Key Parameters on Moment Capacity (BS 8110, 1997)

	Value of Key Parameters Provided during Construction (y_i)							**Effect of Key Parameters on Forth root of Moment Capacity (M_{cy})**					
% change w	**f_y (N/mm^2)**	**Φ (mm)**	**S_t (mm)**	**d_{pr} (mm)**	**f_{cu} (N/mm^2)**	**Total M_{ci}** (kNm)	**Forth root of total M_c**(kNm)	**M_{cfy} (kNm)**	**$M_{c\Phi}$ (kNm)**	**M_{cSt} (kNm)**	**M_{cd} (kNm)**	**M_{cfcu} (kNm)**	μ
0.00	500.000	12.000	300.000	150.000	30.000	25.6730	2.2510	0.6863	1.3726	-0.6863	0.8143	0.0640	1.00
1.00	495.000	11.880	297.000	148.500	29.700	24.9105	2.2341	0.6812	1.3623	-0.6812	0.8082	0.0635	0.99
2.00	490.000	11.760	294.000	147.000	29.400	24.1632	2.2171	0.6760	1.3520	-0.6760	0.8021	0.0630	0.98
3.00	485.000	11.640	291.000	145.500	29.100	23.4311	2.2001	0.6708	1.3416	-0.6708	0.7959	0.0626	0.97
4.00	480.000	11.520	288.000	144.000	28.800	22.7138	2.1831	0.6656	1.3312	-0.6656	0.7898	0.0621	0.96
5.00	475.000	11.400	285.000	142.500	28.500	22.0114	2.1660	0.6604	1.3208	-0.6604	0.7836	0.0616	0.95
6.00	470.000	11.280	282.000	141.000	28.200	21.3236	2.1489	0.6552	1.3104	-0.6552	0.7774	0.0611	0.94
7.00	465.000	11.160	279.000	139.500	27.900	20.6503	2.1317	0.6500	1.2999	-0.6500	0.7712	0.0606	0.93
8.00	460.000	11.040	276.000	138.000	27.600	19.9913	2.1145	0.6447	1.2894	-0.6447	0.7650	0.0601	0.92
9.00	455.000	10.920	273.000	136.500	27.300	19.3464	2.0973	0.6394	1.2789	-0.6394	0.7587	0.0596	0.91
10.00	450.000	10.800	270.000	135.000	27.000	18.7156	2.0799	0.6342	1.2683	-0.6342	0.7525	0.0591	0.90
11.00	445.000	10.680	267.000	133.500	26.700	18.0987	2.0626	0.6289	1.2578	-0.6289	0.7462	0.0586	0.89
12.00	440.000	10.560	264.000	132.000	26.400	17.4954	2.0452	0.6236	1.2471	-0.6236	0.7399	0.0581	0.88
13.00	435.000	10.440	261.000	130.500	26.100	16.9058	2.0277	0.6182	1.2365	-0.6182	0.7336	0.0577	0.87
14.00	430.000	10.320	258.000	129.000	25.800	16.3295	2.0102	0.6129	1.2258	-0.6129	0.7272	0.0572	0.86
15.00	425.000	10.200	255.000	127.500	25.500	15.7664	1.9927	0.6076	1.2151	-0.6076	0.7209	0.0567	0.85
16.00	420.000	10.080	252.000	126.000	25.200	15.2165	1.9751	0.6022	1.2044	-0.6022	0.7145	0.0562	0.84
17.00	415.000	9.960	249.000	124.500	24.900	14.6795	1.9574	0.5968	1.1936	-0.5968	0.7081	0.0557	0.83
18.00	410.000	9.840	246.000	123.000	24.600	14.1553	1.9397	0.5914	1.1828	-0.5914	0.7017	0.0552	0.82
19.00	405.000	9.720	243.000	121.500	24.300	13.6437	1.9219	0.5860	1.1720	-0.5860	0.6953	0.0546	0.81
20.00	400.000	9.600	240.000	120.000	24.000	13.1446	1.9041	0.5805	1.1611	-0.5805	0.6888	0.0541	0.80
21.00	395.000	9.480	237.000	118.500	23.700	12.6578	1.8862	0.5751	1.1502	-0.5751	0.6824	0.0536	0.79
22.00	390.000	9.360	234.000	117.000	23.400	12.1832	1.8683	0.5696	1.1393	-0.5696	0.6759	0.0531	0.78
23.00	385.000	9.240	231.000	115.500	23.100	11.7206	1.8503	0.5641	1.1283	-0.5641	0.6694	0.0526	0.77
24.00	380.000	9.120	228.000	114.000	22.800	11.2698	1.8322	0.5586	1.1173	-0.5586	0.6628	0.0521	0.76
25.00	375.000	9.000	225.000	112.500	22.500	10.8308	1.8141	0.5531	1.1062	-0.5531	0.6563	0.0516	0.75
26.00	370.000	8.880	222.000	111.000	22.200	10.4033	1.7959	0.5476	1.0952	-0.5476	0.6497	0.0511	0.74
27.00	365.000	8.760	219.000	109.500	21.900	9.9872	1.7777	0.5420	1.0840	-0.5420	0.6431	0.0505	0.73
28.00	360.000	8.640	216.000	108.000	21.600	9.5824	1.7594	0.5364	1.0729	-0.5364	0.6365	0.0500	0.72
29.00	355.000	8.520	213.000	106.500	21.300	9.1887	1.7411	0.5308	1.0617	-0.5308	0.6299	0.0495	0.71
30.00	350.000	8.400	210.000	105.000	21.000	8.8058	1.7226	0.5252	1.0505	-0.5252	0.6232	0.0490	0.70
31.00	345.000	8.280	207.000	103.500	20.700	8.4338	1.7041	0.5196	1.0392	-0.5196	0.6165	0.0485	0.69
32.00	340.000	8.160	204.000	102.000	20.400	8.0724	1.6856	0.5139	1.0279	-0.5139	0.6098	0.0479	0.68
33.00	335.000	8.040	201.000	100.500	20.100	7.7215	1.6670	0.5082	1.0165	-0.5082	0.6031	0.0474	0.67
34.00	330.000	7.920	198.000	99.000	19.800	7.3809	1.6483	0.5025	1.0051	-0.5025	0.5963	0.0469	0.66
35.00	325.000	7.800	195.000	97.500	19.500	7.0505	1.6295	0.4968	0.9937	-0.4968	0.5895	0.0463	0.65
36.00	320.000	7.680	192.000	96.000	19.200	6.7300	1.6107	0.4911	0.9822	-0.4911	0.5827	0.0458	0.64
37.00	315.000	7.560	189.000	94.500	18.900	6.4195	1.5917	0.4853	0.9706	-0.4853	0.5758	0.0453	0.63
38.00	310.000	7.440	186.000	93.000	18.600	6.1186	1.5728	0.4795	0.9591	-0.4795	0.5690	0.0447	0.62
39.00	305.000	7.320	183.000	91.500	18.300	5.8273	1.5537	0.4737	0.9474	-0.4737	0.5621	0.0442	0.61
40.00	300.000	7.200	180.000	90.000	18.000	5.5454	1.5346	0.4679	0.9358	-0.4679	0.5552	0.0436	0.60

41.00	295.000	7.080	177.000	88.500	17.700	5.2727	1.5153	0.4620	0.9240	-0.4620	0.5482	0.0431	0.59
42.00	290.000	6.960	174.000	87.000	17.400	5.0091	1.4960	0.4561	0.9123	-0.4561	0.5412	0.0425	0.58
43.00	285.000	6.840	171.000	85.500	17.100	4.7545	1.4766	0.4502	0.9005	-0.4502	0.5342	0.0420	0.57
44.00	280.000	6.720	168.000	84.000	16.800	4.5086	1.4572	0.4443	0.8886	-0.4443	0.5272	0.0414	0.56
45.00	275.000	6.600	165.000	82.500	16.500	4.2713	1.4376	0.4383	0.8767	-0.4383	0.5201	0.0409	0.55
46.00	270.000	6.480	162.000	81.000	16.200	4.0426	1.4180	0.4323	0.8647	-0.4323	0.5130	0.0403	0.54
47.00	265.000	6.360	159.000	79.500	15.900	3.8221	1.3982	0.4263	0.8526	-0.4263	0.5058	0.0398	0.53
48.00	260.000	6.240	156.000	78.000	15.600	3.6098	1.3784	0.4203	0.8405	-0.4203	0.4987	0.0392	0.52
49.00	255.000	6.120	153.000	76.500	15.300	3.4056	1.3585	0.4142	0.8284	-0.4142	0.4914	0.0386	0.51
50.00	250.000	6.000	150.000	75.000	15.000	3.2091	1.3384	0.4081	0.8162	-0.4081	0.4842	0.0381	0.50