Calculation of Breaking Load of EC Grade Aluminium wire as per International Standard

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Abstract – *Breaking Load of E C Grade Aluminium Wire is very difficult to find out mathematically because there is a lots of factors behind to develop the breaking load of wire (eg. Stress, Percentage of Die reduction, Columb's Effect etc.). Considering all the factors and practical observation this formula/Equation made to calculate the breaking load of E C Grade Aluminium wire. Which may fulfill the general requirement of the breaking load of E C Grade Aluminium wire as per International Standard i.e. IEEE, IEC, ASTM, BS, DIN, JIS, BIS etc.*

Key Words: UTS of E C Grade aluminium wire, Breaking load of E C Grade Aluminium Wire, E C Grade Aluminium wire for overhead transmission, AAC Bare Conductor for Overhead Transmission Line, ACSR Conductor for Overhead Transmission Line.

1.INTRODUCTION

E C Grade Aluminium Wire & Conductor is the distinctive features of our modern civilization. A wide range of uses of 'E C Grade Aluminium Wire & Conductor' both in domestically & industrially. E C Grade Aluminium Conductor made by Stranding processes of multiple wires as per National or International Standard.

Breaking Load of E.C. Grade Aluminium Wire for Overhead Transmission is one of the most important factor in Specification to screening out the Technical Parameters. As per the purchasers demand, some time we have to calculate Breaking Load of Wire (non specified Wire Diameter in Specification) based on any of the above standard. With the help of "Interpolation" UTS (Kgf/mm^2) of the wire may calculate to satisfy the Customer. Some time the Breaking Load (Kgf/KN) does not tally with the purchasers Specification or Demand because there is no General Formula Existing in any Specification.

I agreed with the opinion Published in Journal of "Materials Processing Technology" 162-163|(2005) 551-557 . Breaking load of EC Grade Aluminium Wire is very difficult to find mathematically, because there is a lot of factors behind to develop the breaking load of Wire such as 1) Drawing process , 2)Percentage of reduction, 3)Tension in drawing process, 4)Friction between the work piece i.e. Coulomb's effect, 5) Lubrication 6) chemical composition 7)Stress etc. Non uniform Die angle may not follow the coulomb constant. Die angle lies between 15^0 - 25^0 and may be more than that . Die Angle depend on Wire Drawing Machine System .

2. DERIVATION

Minimum Breaking Load of EC Grade Aluminium Wire= [{UTS of Wire(in Kgf/mm^2) x Cress-Sectional Area(in mm^2)}/102] KN

Tensile Strength of Wire develop due to stress apply on drawn wire during Wire drawing stages and secondly tensile strength develop by the angular pressure of die.

Stress could not measure directly, only we can calculate it from different formula. When wire passes through the multiple dies the flexible stress applied on the wire because uniform die reduction could not maintained due to the various type of wire drawing machine. Standard reduction consider in respect to all wire drawing machine is 20%-25% which may not constant.

Tensile strength increase due to stress maximum upto 80% of tensile strength of EC Grade Aluminium Wire Rod.

Tensile Strength of wire = Tensile Strength of Rod + 80% of the Tensile Strength of Rod = [85 + (85 x 80%)] MPa = 153MPa = 15.606 Kgf/mm^2…………………… eq. (i)

[where, Minium Tensile Strength of Aluminium Wire Rod = 85 MPa (Range=II as per IS:5484-1997)

Secondly, Tensile Strength of wire increase due to another factor i.e. die angle pressure, known as Columb effect. For EC Grade Aluminum Wire die angle pressure observed practically is differ from the Columb's factor. For the EC Grade Auminium wire the value of the factor is **0.1293 Kgf/mm^2** , which is **Pranab's Constant (P_d)** obtain experimentally.

Tensile Strength Increase = $[(\pi d^2/4)/(\pi D^2/4)]*P_d$ Kgf/mm^2 = (11.67/D^2) Kgf/mm^2……………………….. eq. (ii)

[Where, d = Aluminium Wire Rod diameter = 9.5 mm (as per Standard) and, D= Required Wire Diameter in (mm)].

So, Tesile Strength of the wire = eq. (i) + eq. (ii) = $[15.606+(11.67/D^2)]$ Kgf/mm^2 .

Minimum Breaking Load of the Wire = [{UTS of Wire(in Kgf/mm^2) x Cress-Sectional Area(in mm^2)] Kgf = $[\{15.606+(11.67/D^2)\} \times \frac{\pi D^2}{4}]$ Kgf = $\mathbf{[\{15.606 + (11.67/D^2)\} \times \frac{\pi D^2}{4}]/102}$ **KN =** $\mathbf{[0.120166D^2 + 0.089859]}$ **KN**

Table -1: Comparing Calculated B/L with IEC-61089 Specification.

Dia in (MM)	B/L from specification in (KN)	Calculated B/L Value in(KN)	Deviation (KN)
1.35	0.28	0.31	-0.03
1.71	0.43	0.44	-0.01
2.13	0.64	0.64	0.01
2.59	0.89	0.90	0.00
2.70	0.97	0.97	0.01
2.89	1.12	1.09	0.02
3.27	1.39	1.37	0.01
3.29	1.40	1.39	0.01
3.39	1.48	1.47	0.01
3.63	1.65	1.67	-0.02
3.66	1.68	1.70	-0.02
3.71	1.73	1.74	-0.01
3.85	1.86	1.87	-0.01
3.94	1.95	1.96	-0.01
3.96	1.97	1.97	-0.01
4.09	2.11	2.10	0.01
4.09	2.10	2.10	0.00
4.15	2.16	2.16	0.00
4.18	2.20	2.19	0.01
4.33	2.36	2.34	0.02
4.39	2.41	2.41	0.00
4.43	2.46	2.45	0.01
4.58	2.64	2.61	0.03

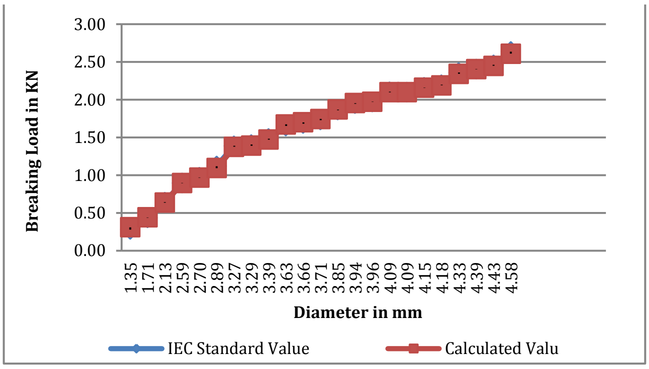


Chart -1: Comparing Calculated B/L with IEC-61089 Specification.

Table -2: Comparing Calculated value with IS:398(Part1 &2) 1996.

Dia Of Wire(mm)	Breaking Load in (KN) as per Specification	Calculated Breaking Load in (KN)
1.37	0.32	0.32
1.50	0.32	0.36
1.96	0.54	0.55
2.11	0.63	0.62
2.21	0.68	0.68
2.59	0.89	0.90
3.00	1.17	1.17
3.10	1.24	1.24
3.18	1.29	1.31
3.35	1.43	1.44
3.50	1.55	1.56
3.53	1.57	1.59
3.80	1.80	1.83
3.99	1.98	2.00
4.09	2.08	2.10
4.13	2.13	2.14
4.39	2.40	2.41
4.65	2.70	2.69
4.72	2.78	2.77

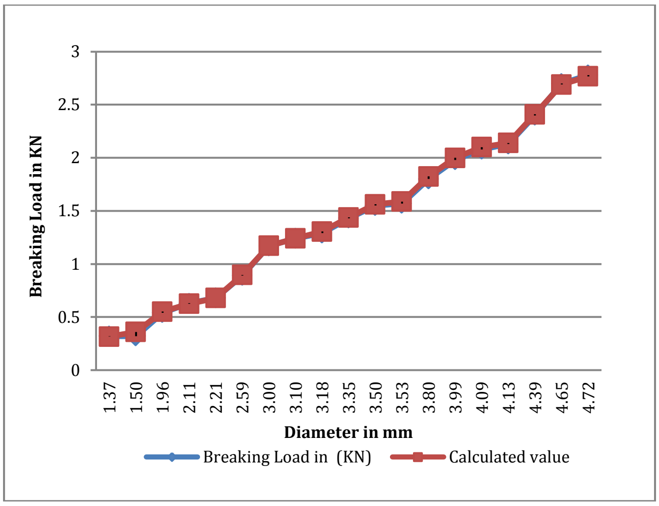


Chart -2: Comparing Calculated value with IS:398(Part1 &2) 1996.

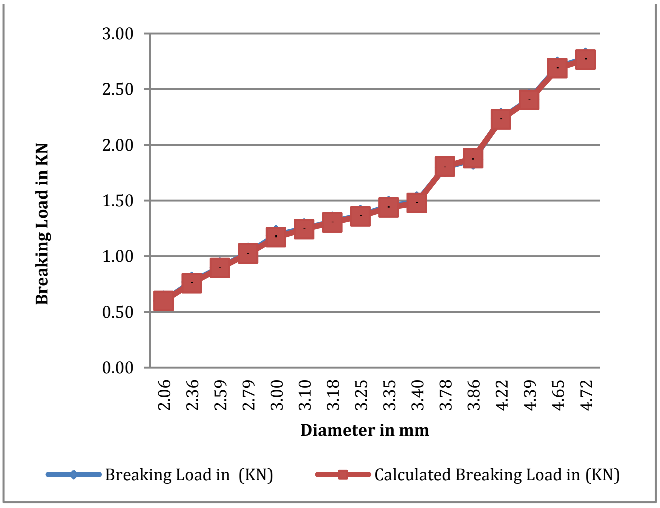


Chart -3: Comparing Calculated Breaking load with BS:215(Part 1 & 2)1970.

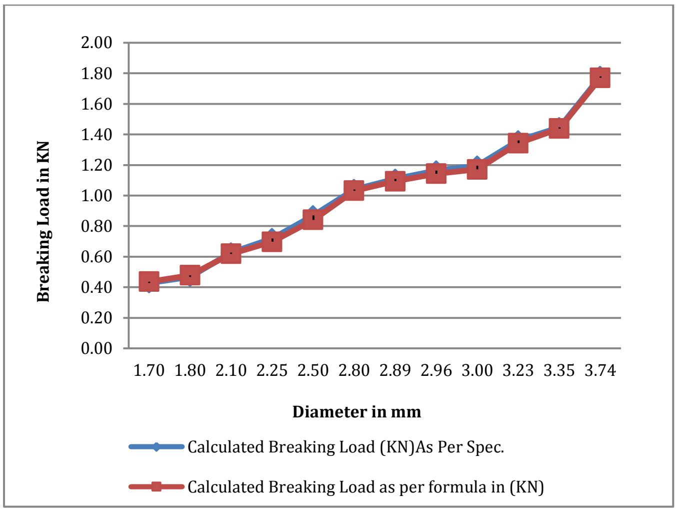
Table -3: Comparing Calculated Breaking load with BS:215(Part 1 & 2)1970.

Dia(mm)Of Wire	Breaking Load in (KN)	Calculated Breaking Load in (KN)
2.06	0.60	0.60
2.36	0.77	0.76
2.59	0.90	0.90
2.79	1.03	1.03
3.00	1.19	1.17
3.10	1.25	1.24
3.18	1.31	1.31
3.25	1.37	1.36
3.35	1.45	1.44
3.40	1.49	1.48
3.78	1.80	1.81
3.86	1.87	1.88
4.22	2.24	2.23
4.39	2.41	2.41
4.65	2.70	2.69
4.72	2.78	2.77

Table -4: Comparing Calculated Breaking Load with DIN-EN50182-2001-12.

Diameter in (mm)	Calculated Breaking Load (KN)As Per Spec.	Calculated Breaking Load (KN)
1.70	0.43	0.44
1.80	0.47	0.48
2.10	0.63	0.62
2.25	0.72	0.70
2.50	0.87	0.84
2.80	1.04	1.03
2.89	1.11	1.09
2.96	1.16	1.14
3.00	1.19	1.17
3.23	1.36	1.34
3.35	1.45	1.44
3.74	1.78	1.77

Chart -4: Comparing Calculated Breaking Load with DIN-EN50182-2001-12.



3. CONCLUSIONS

This Formula covers the requirement of Breaking Load of E.C Grade Aluminium (AAC & ACSR , ACAR) used for overhead power transmission . This formula may help to calculate the Breaking Load of EC Grade Aluminium Wire from 5.50mm to 1.25mm. UTS of wire will be increase or decrease in proper manner. In this process the breaking Load will maintain in order.

As we can see from the above chart and graph, that calculated value of Breaking Load by using the derived formula giving the results very close to the Standard Values. The Small deviation found between the calculated value and the specified value because:-

1. Chemical Compositions of EC Grade Aluminium Rod.
2. Error in Experimental Setup.
3. Lubricant Temperature & types of lubricant.
4. Type of Drawing Machine (Slip type, Non-Slip Type).
5. RPM of Machine.
6. Area reduction of dies.
7. Angle of the die.

REFERENCES

[1] IEC : 61089.
[2] IS : 398 (Part-1&2) 1996.
[3] BS : 215 (Part-1&2) 1970.
[4] DIN - EN50182-2001-12 (part-5).
[5] ASTM : B231 &B232.
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BIOGRAPHIES

Pranab Mukherjee passed B.Sc, D.M.L.T & having 35 years of industrial experience in Wire & Conductor Manufacturing Unit. He has works for many companies including GROUPS OF USHA MARTIN , INDO AMERICAN ELECTRICAL LTD. and many other companies as a Quality Control Engineer. Now he is working for M/s. CABCON IND. PVT. LTD. As Technical Consultant. His field of interest is Standing and Wire Drawing.

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