Comparative Study of Wind Load effects for Transmission Towers Using IS 802 And AS/NZS 7000

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Abstract - *Wind load governs the design of overhead transmission towers due to their height, slender members, and continuous exposure to atmospheric actions. Different design standards adopt different representations of wind characteristics and gust effects, resulting in variation in estimated wind forces and structural response. IS 802 (Part 1/Sec 1):2015 evaluates wind load by converting a 3-second gust wind speed into an equivalent mean wind speed and applying gust response factors. In contrast, AS/NZS 7000:2016 directly uses the 3-second gust wind speed with terrain, shielding, and span-related modification factors and allows separate consideration of synoptic and downdraft wind mechanisms.*

In the present study, wind forces on transmission tower components are evaluated using IS 802 (Part 1/Sec 1):2015 and AS/NZS 7000:2016 under identical site conditions. A 132 kV and a 220 kV suspension-type lattice tower are modeled and analyzed using STAAD Pro. Wind forces on conductors, earth wires, and tower body, along with resulting member forces, are compared. The results show that IS 802 generally produces higher forces under synoptic wind conditions, while the difference reduces significantly when downdraft wind provisions of AS/NZS 7000 are considered. This indicates that the higher forces in IS 802 mainly arise from its gust factor–based approach.

Keywords: Transmission tower, Wind load, IS 802, AS/NZS 7000, Synoptic wind, Downdraft wind

1.INTRODUCTION

Transmission towers are critical structures for power transmission and are highly sensitive to wind loading due to their tall height, open lattice configuration, and long conductor spans. Wind load estimation plays a major role in the design of tower members, foundations, and even moderate variation in wind forces can significantly affect structural safety and economy.

In India, transmission towers are designed in accordance with IS 802 (Part 1/Sec 1):2015, which evaluates wind effects using a mean wind speed combined with gust response factors. International standards such as AS/NZS 7000:2016 adopt a different approach by directly using the 3-second gust wind speed along with terrain, shielding, and span modification factors. AS/NZS 7000 also permits separate consideration of synoptic and downdraft wind mechanisms, which is not explicitly addressed in IS 802.

Understanding the differences between these approaches is important for evaluating the relative conservatism of wind load provisions and their influence on transmission tower design. The present study compares wind forces and structural response obtained from IS 802 and AS/NZS 7000 through analytical modelling and numerical analysis of typical transmission towers.

2. WIND LOAD PROVISIONS IN DESIGN STANDARDS

Wind load on transmission towers depends on wind speed definition, terrain exposure, height variation, gust effects, and spatial correlation along conductor spans. IS 802 (Part 1/Sec 1):2015 and AS/NZS 7000:2016 adopt different formulations for these parameters, leading to variations in calculated wind forces.

2.1 Wind Load Provisions as per IS 802 (Part 1/Sec 1):2015

IS 802 defines the basic wind speed as a 3-second gust at 10 m above ground level. For design, this gust wind speed is converted to an equivalent mean wind speed using terrain and height factors. Gust effects on conductors, insulators, and tower members are incorporated through gust response factors.

2.2 Wind Load Provisions as per AS/NZS 7000:2016

AS/NZS 7000 uses the 3-second gust wind speed directly for design, modified by direction, terrain, shielding, and topographic multipliers. Gust effects are inherently included, and no separate gust response factor is applied. For conductors, span reduction factors account for spatial correlation, while tower body forces are evaluated using force coefficients based on member shape and solidity ratio.

2.3 Synoptic and Downdraft Wind Models in AS/NZS 7000

AS/NZS 7000 allows different wind models based on the governing wind mechanism. Synoptic winds represent large-scale wind systems with relatively uniform wind fields, where span reduction factors significantly reduce conductor forces. Downdraft winds are short-duration, localized, high-intensity winds associated with convective storms, resulting in higher local wind pressures and reduced effectiveness of span reduction factors.

2.4 Relevance to Transmission Towers in Indian Conditions

In many parts of India, severe winds affecting transmission lines are commonly associated with thunderstorms and convective activity, which exhibit downdraft-type behavior. IS 802 indirectly accounts for such effects through gust response factors, leading to higher wind force estimates.

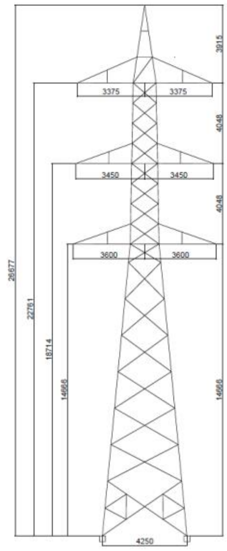
The results of the present study indicate that when downdraft wind provisions of AS/NZS 7000 are applied, the difference between IS 802 and AS/NZS 7000 reduces compared to synoptic wind conditions, particularly for conductors at lower heights. However, IS 802 continues to predict higher wind forces on conductors and tower body across most height and span ranges. This indicates that the higher forces obtained from IS 802 primarily arise from its gust factor–based formulation, which introduces increasing conservatism with height, rather than from differences in basic wind speed definition.

3. Methodology

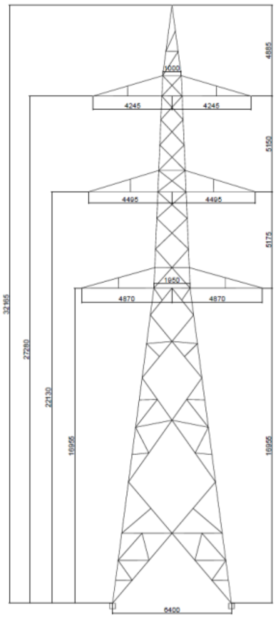
Based on the above understanding of wind load modelling approaches, numerical wind force calculations and structural analyses are performed for representative 132 kV and 220 kV suspension type transmission towers. Wind loads are evaluated using IS 802 (Part 1/Sec 1):2015 and AS/NZS 7000:2016 under identical site and terrain conditions, considering both synoptic and downdraft wind models. The resulting forces on conductors, insulators, tower body, and overall structural responses are compared to quantify the influence of each standard.

3.1. Tower geometry

a) Tower geometry for 132kV Tower
No. of circuit: Double circuit
Angle of deviation: 0-to-2-degree deviation
Tower type: Suspension tower
Span length: 260m
Total height: 26.677m
Height of top conductor: 22.71m
Height of Middle conductor:18.714m
Height of bottom conductor: 14.666m
Base width of tower: 4.250m
Conductor: ACSR Panther
Optical ground wire = 48 fibers



b) Tower geometry for 220kV Tower
No. of circuit: Double circuit
Angle of deviation: 0-to-2-degree deviation
Tower type: Suspension tower
Span length: 350m
Total height: 32.165m
Height of top conductor: 27.280m
Height of Middle conductor:22.130m
Height of bottom conductor: 16.955m
Base width of tower: 6.4m
Conductor: ACSR Zebra
Optical ground wire = 48 fibers



3.2. Wind speed Parameters

The following parameters are used for both standards:

Basic wind speed (3-second gust): 47 m/s
Terrain category: Open terrain
Air density: 1.225 kg/m^3

3.3. Tower forces evaluation as per IS 802 (Part 1/Sec 1):2015

1) Forces evaluation for 132kV Tower

a) Wind force on conductor (Fwc)

Fwc = P_d x A x Cd x Gt
Were,
P_d = Design wind pressure = 0.6 V_d^2
V_d = Design wind speed = V_R x K_1 x K_2
V_R = Reference wind speed = V_b / K_0
K_1 = Risk coefficient
K_2 = Terrain roughness coefficient
K_0 = 1.375
L = Wind span, in m
d = diameter of conductor, in m
C_{dc} = Drag coefficient, 1.0 for conductor
1.2 for Earth wire/OPGW
Gc = Gust response factor, as per Table 7.

For Wind speed 47 m/s
Design wind pressure,
P_d = 0.6 x $(47/1.375)^2$ x 1 x 1 ,(K_1 & K_2 = 1)
P_d = 701.04 N/m^2
Force on conductor
Fwc = 701.04 x 260 x 0.021 x 1 x 2.09
= 8000 N

b) Wind force on OPGW (Fwc)

Fwc = P_d x A x Cd x Gt
Fwc = 701.04 x 260 x 0.0121 x 1.2 x 2.09
= 5531.31N

c) Wind force on Insulator (Fwi)

Fwi = P_d x A x G x Cdt
= 701.04 x 2.0 x 0.3 x 2.2 x 1.2
= 1110.44 N

d) Wind force on tower body (Fwt)

Fwt = P_d x A x Cd x GT
A = net area of tower
Cd = Drag coefficient of tower based on solidity ration, as per table 5,
Solidity ratio = Net area / Total area
= 13.98 / 63.96 = 0.22
Cd =3.42
Fwt = 701.04 x 13.98 x 3.42x 2.2
= 73739N
Nos. of nodes = 57
Load on each node = 73739/57
= 1293.67N

e) Self-weight of conductor

Vc = Span length x unit weight
= 260 x 9.55 = 2483 N

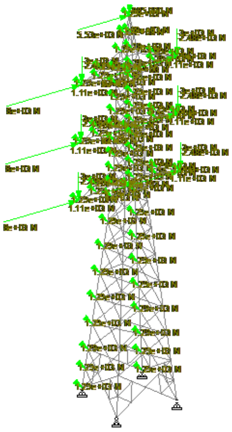
f) Self-weight of OPGW

Vc = Span length x unit weight
= 260 x 3.79 = 985 N

g) Self-weight of insulator and man-tools load

Vi = 300kg = 3000N

h) Staad model for 132kV Tower :



2) Forces evaluation for 220kV Tower

a) Wind force on conductor (Fwc)

Fwc = P_d x A x Cd x Gt
P_d , same as above calculation
P_d = 701.04 N/m^2
Force on conductor
Fwc = 701.04 x 350 x 0.02862 x 1 x 2.16
= 15168.2 N

b) Wind force on OPGW (Fwc)

Fwc = P_d x A x Cd x Gt
Fwc = 701.04 x 350 x 0.0121 x 1.2 x 2.16
= 7695.38 N

c) Wind force on Insulator (Fwi)

Fwi = P_d x A x G x Cdt
= 701.04 x 3.0 x 0.3 x 2.3 x 1.2
= 1741.38 N

d) Wind force on tower body (Fwt)

Fwt = P_d x A x Cd x GT
A = net area of tower
Cd = Drag coefficient of tower based on solidity ration, as per table 5,
Solidity ratio = Net area / Total area
= 17.95 / 110.96 = 0.162
Cd = 3.50
Fwt = 701.04 x 17.95 x 3.50 x 2.3
= 101298 N

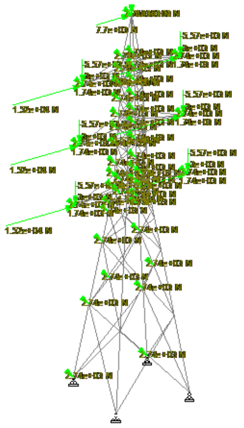
Nos. of nodes = 37
Load on each node = 101298/37
= 2737.79 N

e) Self-weight of conductor
Vc = Span length x unit weight
= 350 x 15.90 = 5565.71 N

f) Self-weight of OPGW
Vc = Span length x unit weight
= 350 x 3.79 = 1326.5 N

g) Self-weight of insulator and man-tools load
Vi = 300kg = 3000N

h) Staad model for 220kV Tower :



3.4. Tower forces evaluation as per AS/NZS 7000:2016, Considering synoptic wind condition

1) Forces evaluation for 132kV Tower

a) Wind force on conductor (Fc)
Fc= q_z x Cd x L X d x SRF x COS^{2}α
Were,
q_z = Design wind pressure = 0.6 x $V^2_{sit,\beta}$
$V_{sit,\beta}$ = Design site wind speed
= V_R x M_d x $M_{z,cat}$ x M_s x M_t
V_R = Basic regional wind velocity
M_d = Wind direction multiplier
$M_{z,cat}$ = Gust wind speed multiplier for terrain category at height Z
M_s = Shielding multiplier
M_t = Topographic multiplier
L = Wind span, in m
d = diameter of conductor, in m
α = Angle of wind direction, = 0
Cd = Drag coefficient, 1.0 for conductor
SRF = Span reduction factor

For Wind speed 47 m/s
V_R = 47m/s
M_d = 1.0
$M_{z,cat}$ = 1.09
M_s = 1.0
M_t = 1.0

Design wind pressure,
q_z = 0.6 x (47x 1.09)^2
P_d = 1574.71 N/m^2
Force on conductor
Fc = 1574.71 x 1.0 x 260 x 0.021 x 0.725
= 6233.48 N

b) Wind force on OPGW (Fc)
Fc = q_z x Cd x L X d x SRF x COS^{2}α
= 1574.71 x 1.2 x 260 x 0.0121 x 0.725
= 4310.01 N

c) Wind force on Insulator (Fi)
Fi = q_z x Cd x A
= 1574.71 x 1.2 x 2.0 x 0.3
= 1133.79 N

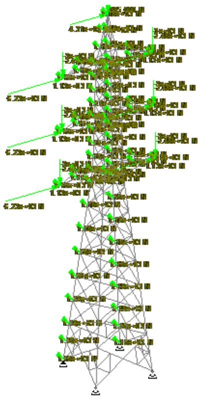
d) Wind force on tower body (Fs)
F_s = q_z x Cd x A x COS^{2}α
A = member area = 13.98 m^2
Cd= 3.06
F_s = 1574.71 x 3.06 x 13.98
= 67364.10 N
Nos. of nodes = 57
Load on each node = 67364.10/57
= 1181.83 N

e) Self-weight of conductor
Vc = Span length x unit weight
= 260 x 9.55 = 2483 N

f) Self-weight of OPGW
Vc = Span length x unit weight
= 260 x 3.79 = 985 N

g) Self-weight of insulator and man-tools load
Vi = 300kg = 3000N

h) Staad model for 132kV Tower :



2) Forces evaluation for 220kV Tower

a) Wind force on conductor (Fc)

Fc= q_z x Cd x L X d x SRF x $COS^2\alpha$
Were,
V_R = 47m/s
M_d = 1.0
$M_{z,cat}$ = 1.12
M_s = 1.0
M_t = 1.0

Design wind pressure,
q_z = 0.6 x $(47 x 1.12)^2$
P_d = 1662.58 N/m^2
Force on conductor
Fc = 1662.58 x 1.0 x 350 x 0.02862 x 0.675
= 11241.58N

b) Wind force on OPGW (Fc)

Fc = q_z x Cd x L X d x SRF x $COS^2\alpha$
= 1662.58 x 1.0 x 350 x 0.0121 x 0.675
= 4752.70 N

c) Wind force on Insulator (Fi)

Fi = q_z x Cd x A
= 1662.58 x 1.2 x 3.0 x 0.3
= 1795.59 N

d) Wind force on tower body (Fs)

F_s = q_z x Cd x A x $COS^2\alpha$
A = member area = 17.95 m^2
Cd = 3.13
F_s = 1662.58 x 3.13 x 17.95
= 93409.7 N
Nos. of nodes = 37
Load on each node = 93409.7/37
= 2524.59 N

e) Self-weight of conductor

Vc = Span length x unit weight
= 350 x 15.90 = 5565.71 N

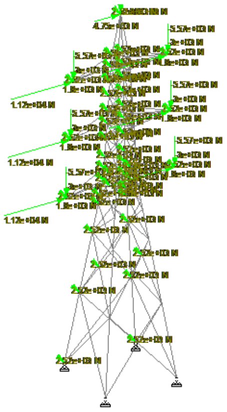
f) Self-weight of OPGW

Vc = Span length x unit weight
= 350 x 3.79 = 1326.5 N

g) Self-weight of insulator and man-tools load

Vi = 300kg = 3000N

h) Staad model for 220kV Tower :



3.4. Tower forces evaluation as per AS/NZS 7000:2016, Considering downdraft wind

3) Forces evaluation for 132kV Tower

a) Wind force on conductor (Fc)

Fc= q_z x Cd x L X d x SRF x $COS^2\alpha$
V_R = 47m/s
M_d = 1.0
$M_{z,cat}$ = 1.0
M_s = 1.0
M_t = 1.0
SRF = 1.0
Design wind pressure,
q_z = 0.6 x $(47 x 1.00)^2$
P_d = 1325.40 Ns/m^2
Force on conductor
Fc = 1325.40 x 1.0 x 260 x 0.021 x 0.98
= 7091.95 N

b) Wind force on OPGW (Fc)

Fc = q_z x Cd x L X d x SRF x $COS^2\alpha$
= 1325.40 x 1.2 x 260 x 0.0121 x 0.98
= 4903.58 N

c) Wind force on Insulator (Fi)

Fi = q_z x Cd x A
= 1325.40 x 1.2 x 2.0 x 0.3
= 954.288 N

d) Wind force on tower body (Fs)

F_s = q_z x Cd x A x $COS^2\alpha$
A = member area = 13.98 m^2
Cd = 3.06
F_s = = 1325.40 x 3.06 x 13.98

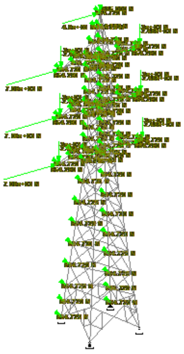
= 56699 N
Nos. of nodes = 57
Load on each node = 56699/57
= 994.72 N

e) Self-weight of conductor
Vc = Span length x unit weight
= 260 x 9.55 = 2483 N

f) Self-weight of OPGW
Vc = Span length x unit weight
= 260 x 3.79 = 985 N

g) Self-weight of insulator and man-tools load
Vi = 300kg = 3000N

h) Staad model for 132kV Tower :



4) Forces evaluation for 220kV Tower

a) Wind force on conductor (Fc)
Fc= q_z x Cd x L X d x SRF x $COS^2\alpha$
Fc = 1325.40 x 1.0 x 350 x 0.02862 x 0.953
= 12652.53N

b) Wind force on OPGW (Fc)
Fc = q_z x Cd x L X d x SRF x $COS^2\alpha$
= 1325.4 x 1.0 x 350 x 0.0121 x 0.953
= 5349.25 N

c) Wind force on Insulator (Fi)
Fi = q_z x Cd x A
= 1325.40 x 1.2 x 3.0 x 0.3
= 715.72N

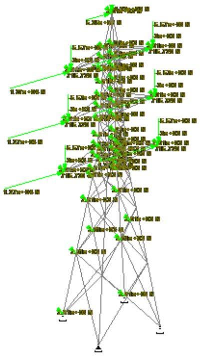
d) Wind force on tower body (Fs)
F_s = q_z x Cd x A x $COS^2\alpha$
A = member area = 17.95 m^2
Cd = 3.13
Fs = 1325.40 x 3.13 x 17.95
= 74465.6 N
Nos. of nodes = 37
Load on each node = 74465.6/37
= 2012.58 N

e) Self-weight of conductor
Vc = Span length x unit weight
= 350 x 15.90 = 5565.71 N

f) Self-weight of OPGW
Vc = Span length x unit weight
= 350 x 3.79 = 1326.5 N

g) Self-weight of insulator and man-tools load
Vi = 300kg = 3000N

Particular	IS 802 : (PART 1 /SEC 1) :2015	AS/NZS 7000 :2016 (synoptic wind)	% Difference w.r.t I
Wind force on conductor for 132kV Tower	8000.00 N	6233.48 N	22%
Wind force on tower body for 132kV Tower	73739 N	39075.60 N	9%
Max. compressive force for 132kV Tower	295441.74 N	201175.72 N	13%
Max. tensile force for 132kV Tower	265627.32 N	171169.19 N	15%
Max. Shear force for 132kV Tower	1912.10 N	1617.56 N	8%
Wind force on conductor for 220kV Tower	15168.20 N	11241.58 N	26%
Wind force on tower body for 220kV Tower	101298.00 N	54911.80 N	8%
Max. compressive force for 220kV Tower	384312.19 N	322999.63 N	16%
Max. tensile force for 220kV Tower	345422.06 N	283927.43 N	18%
Max. shear force for 220kV Tower	1317.60 N	1152.05 N	13%



h) Staad model for 220kV Tower

4.0. Result and comparison

Particular	IS 802 : (PART 1 /SEC 1) :2015	AS/NZS 7000 :2016 (downdraft wind)	% Difference w.r.t. IS 802
Wind force on conductor for 132kV Tower	8000.00 N	7091.95 N	11%
Wind force on tower body for 132kV Tower	73739 N	56699.00 N	23%
Max. compressive force for 132kV Tower	295441.74 N	246314.59 N	17%
Max. tensile force for 132kV Tower	265627.32 N	216404.80 N	19%
Max. Shear force for 132kV Tower	1912.10 N	1756.07 N	8%
Wind force on conductor for 220kV Tower	15168.20 N	12652.53 N	17%
Wind force on tower body for 220kV Tower	101298.00 N	74465.60 N	26%
Max. compressive force for 220kV Tower	384312.19 N	297035.43 N	23%
Max. tensile force for 220kV Tower	345422.06 N	257526.37 N	25%
Max. shear force for 220kV Tower	1317.60 N	1072.76 N	19%

5.0 DISCUSSION

a) IS 802 produces higher conductor forces under synoptic wind (22–26%) mainly due to the application of gust response factors after converting gust wind speed to mean wind speed, which increases wind demand on flexible components.

b) AS/NZS 7000 predicts lower conductor forces under synoptic wind because span reduction factors account for reduced spatial correlation of wind pressure over long spans, significantly moderating conductor loads.

c) Tower body forces under synoptic wind show limited variation (within about ±10%) between the two standards, indicating similar treatment of force coefficients and height-dependent wind profiles for lattice structures.

d) Under downdraft wind conditions, AS/NZS 7000 results in progressively higher wind forces with increasing height, reducing the influence of span reduction and leading to larger differences with IS 802 (up to ~15% for conductors , ~25% for tower body and , ~20% for member forces).

e) Structural analysis confirms that member axial forces and base reactions directly reflect the applied wind load trends, with IS 802 consistently yielding higher internal forces due to its more conservative gust treatment.

6.0 CONCLUSIONS

a) Wind forces on conductors obtained using IS 802 are consistently higher than those from AS/NZS 7000, with differences of about 22–26% under synoptic wind conditions.

b) Under downdraft wind conditions, the difference in conductor wind force increases with height, ranging from nearly zero at lower heights to about 20% at higher elevations, indicating strong height dependency.

c) Wind force acting on the tower body shows relatively small variation between the two standards under synoptic wind, generally within ±10%, and in some cases AS/NZS 7000 produces marginally higher values.

d) For downdraft wind, tower body forces calculated using IS 802 increases significantly with height, with differences reaching up to 25–30% at higher levels.

e) Structural analysis results indicate that the overall tower response is governed mainly by conductor wind loads, while tower body wind loads have a secondary influence for multi circuit towers.

f) The study highlights that explicit consideration of wind mechanisms such as synoptic and downdraft winds, as provided in AS/NZS 7000, can lead to more rational and transparent wind load assessment for transmission towers

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