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A Prediction Model of MF Radiation in Environmental Assessment

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Objective To predict the impact of MF radiation on human health. **Methods** The vertical distribution of field intensity was estimated by analogism on the basis of measured values from simulation measurement. **Results** A kind of analogism on the basis of geometric proportion decay pattern is put forward in the essay. It showed that with increasing of height the field intensity increased according to geometric proportion law. **Conclusion** This geometric proportion prediction model can be used to estimate the impact of MF radiation on inhabited environment, and can act as a reference pattern in predicting the environmental impact level of MF radiation.

Key words: MF radiation; Electromagnetic environment; Predictive model; Environmental impact assessment

INTRODUCTION

With rapid development of science and technology, keen attention is paid to environmental impact of electromagnetic radiation. As a good conductor, the human body will be caught by the impact of a variety of electromagnetic radiations to a certain extent[1]. To limit electromagnetic radiation impact at a safe range, there must be prediction on environmental impact of electromagnetic radiation for public housing construction. This paper describes a prediction model as a reference pattern for environmental impact assessment of MF radiation.

METHODS

Electromagnetic radiation field was divided into far zone field and near zone field. With radiation source for hub, the internal region at three-wavelength coverage was defined as near zone field or induction field, while the external region was defined as far zone field or radiation field. The emphasis of electromagnetic protection was in near zone field[2]. In regard to mw broadcasting band (535-1605 kHz), RADII of near zone field was 1680 meters around[3].

Theoretical Calculation Model for Electromagnetism Distribution

In order to estimate environmental impact of a radiator, the formula below was used in proximate calculation:

$$E=\frac{300}{r}\sqrt{P\cdot G}\cdot A$$

Where r is space between measuring point and radiator (Km)，P is transmitter nominal power (KW)，G is antenna gain relative to Hertz antenna (dB)，A is ground decay factor.

In the case of multi-radiators, the synthetic field intensity of the measuring point could be calculated according to the formula below, supposing that the incoherence multi-radiators with different frequencies worked on the measuring point simultaneously.

$$\mathbf{E}=\sqrt{\sum\nolimits_{i=1}^{n}E_1^2}$$

The wavelength of radiator, ground surface dielectric coefficient and conductivity possessed complicated dependence with ground decay factor A; usually A was ascertained by experimental means in actual measurement[4].

Measuring Method of Simulation for Electromagnetic Distribution

The formula is an approximate formula on the basis of simplification for antenna efficiency, antenna height, and directivity function of emission angle[5], which is usually used in field intensity estimation for far zone field. In near zone field, the method of direct measurement is commonly adopted[6] because near zone field is a complicated inhomogeneous field and

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calculation by formula could cause significant error. That is to get ground-surface data by on-site measurement, and then to estimate space distribution data, which could not be acquired by on-site measurement by means of analogy.

Derivation of Prediction Model

Statistics showed that logarithm of field intensity had a linear fitting relation with floor height. Linearly dependent coefficient was 0.90. This illustrated that the relationship between space field intensity and floor height conformed to geometric proportion law. Fitting monadic linear regression and deriving the estimated value of ground field intensity E_0, then floor-field intensity relationship could be shown as follows:

$$E = E_0 \cdot q^{H-1}$$

Where E is space field intensity(V/m), E_0 is ground field intensity (V/m), H is floor factor, q is delay ratio.

The formula is a prediction model for space distribution. Differing from approximate formula, the formula is an empirical formula derived from statistics.

Error of Prediction Model

When value q is 1.1-1.2, the error generated by estimation could be shown as follows:

$$W=E_0 \cdot (1.2^{H-1} - 1.1^{H-1})$$

Where E'_0 is the error of field-intensity measured on ground. It was observed that when E_0 increased every 1 V/m, the estimated field intensity on the 20th floor would bring forth a warp of 25 V/m at the most.

RESULTS

Measuring Results

The antenna towers were divided into two sets, a north one and a south one. The distance between the two sets was about 400 meters. The antennas gave off vertically polarized wave with anchored towers. The apparatus for measurement was EMR-300 Field Intensity Meter. We chose three 20-storied high-rises for simulating measurement and measured their field intensity vertical distribution. building No. 1 was located about 800 meters northeast to towers, building No. 2 about 300 meters west to towers, building No. 3 about 400 meters west to towers, and the measuring points 30 cm outside the window facing towers. There were also 7 measuring points on open field south to towers for the horizontal measurement.

Figures 1-3 are floor-field intensity semi-log attenuation curves for buildings No. 1, 2, and 3.

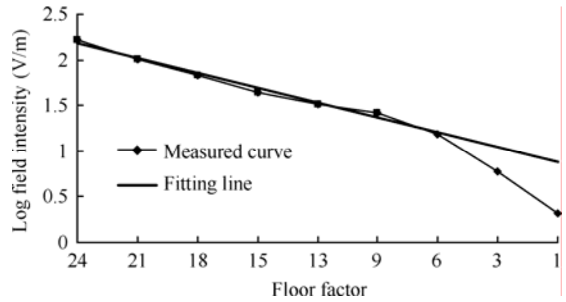

FIG. 1. Attenuation curve for building No. 1.

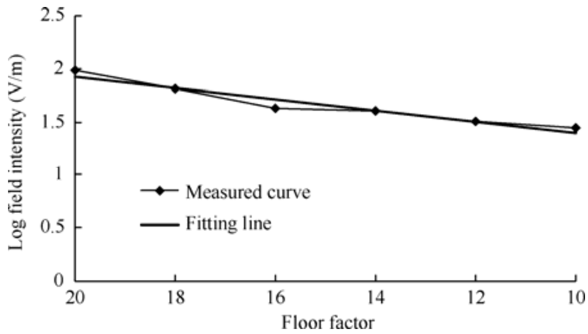

FIG. 2. Attenuation curve for building No. 2.

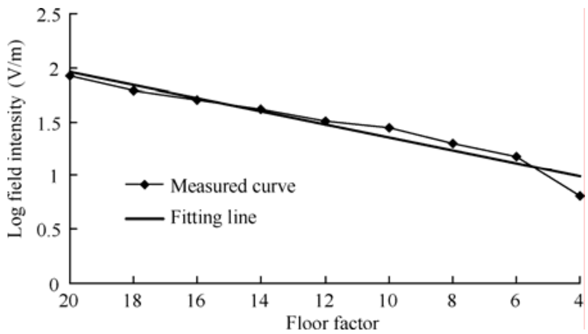

FIG. 3. Attenuation curve for building No. 3.

Table 1 shows the horizontal distribution of field intensity on the ground-surface south to the towers.

TABLE 1

Measured Data (1.5-1.8 m Height)

No.	Distance to Towers	Electric-field Intensity (V/m)
1	780 m	7.13
2	880 m	6.63
3	1050 m	4.14
4	1235 m	3.82
5	1345 m	3.33
6	1580 m	2.78
7	1740 m	2.43

Data Analysis

From Figures above, it was observed that geometric proportion curve could fit the measurement data of upward floors but brought significant errors to downward floors.

Fitting lines are shown in Figs. 1-3. The delay ratios of buildings No. 1, No. 2, and No. 3 were 1.10 and 1.14, respectively. Field-intensity on the ground could be estimated by extrapolation. Estimated values of buildings No. 1, No. 2, and No. 3 were 10. 8 V/m, 7.35 V/m, and 6.68 V/m, respectively. There was a gap between these data and the data measured on the site; the reason might be that built-up high-rise had shielding effect on its surroundings.

Field intensity attenuated rapidly under the height of 10th floor and had less regularity. Statistics showed that there was no effective correlativity of geometric proportion between floor factor and field intensity from 10th floor downwards. This seemed to be caused by probability of ground decay factor.

q was a crucial factor in predictive model. In near zone field q was approximately 1.1- 1.2.

Error Estimation

The error of geometric proportion estimation mostly came from decay ratio q and value E_0 measured on the ground. On the basis of derivative property of geometric progression, the higher the floor was, the larger the variation of field intensity would be. That is to say, the higher the floor over, the more sensitive to decay ratio q and value E_0 the error of estimation would be.

MF wave transmits along ground surface, its propagation loss is primarily due to ground absorption, so value E_0 is not only related to the emission power and space to radiation source, but also to the influence of a good many ambient conditions, such as landform, dielectric properties of earth shallow layer, distribution of surface installations, and atmospheric inhomogeneities, especially in the near zone field with high gradient ratio. Field intensity measured on ground was lower than the estimated value extrapolated according to geometric proportion. Therefore estimation error existed for a certainty. Substituting the value measured on ground in the formula of floor-field intensity, we obtained the estimated value in space as shown in Table 2.

From Table 2, it can be seen that 780 m and 880 m measure points and building No. 1 had similar space to the radiation source. However, when geometric proportion mode of building No. 1 was applied to the two sections, estimating values were on the low side, and the error of estimation at the height of 20th floor reached 40% around.

TABLE 2

Estimated Value of Field Intensity on Floors (V/m)

Floor Factor	10	12	14	15	17	18	19	20
Estimated Value (780 m)	15.6	18.9	22.9	25.2	30.5	33.5	36.9	40.6
Estimated Value (780 m)	16.8	20.3	24.5	27.0	32.7	35.9	39.5	43.5
Measured Value (Building No.1)	25.5	32.5		44.3		55.1		70.2

CONCLUSION

Factors in Vertical Field Intensity Distribution

According to measurement data, vertical field intensity distribution is influenced by ground field intensity, floor factor, and decay ratio. The higher the floor goes over, the higher the field intensity is and the bigger the error is. The farther the space is apart from radiation source, the lower the field intensity on the ground is.

Method for Estimating Field Intensity Distribution

Vertical field intensity distribution could be estimated with empirical formula. In the formula, decay ratio q is related to space, the nearer the space is to the radiation source, the bigger the q is. In near zone field, q value is approximately 1.1-1.2, and actual value can be estimated by simulation measurement.

Estimation Error

Estimation error of geometric proportion modal mostly comes from decay ratio and field intensity measured on ground. The higher the floor goes over, the bigger the error of estimated field intensity is, because q^{H-1} ascends with geometric progression. Usually field intensity measured on ground is lower than estimated field intensity derived by extrapolation; therefore vertical field intensity distribution would be lower than that estimated according to geometric proportion mode.

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