SCATTERED FIELD IN THE VICINITY OF LARGE SQUARE OF THE RECTANGULAR CYLINDER - A NEW METHOD -

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1. INTRODUCTION

The electromagnetic scattered field by a conducting rectangular cylinder has been widely studied by many methods, which are too difficult to obtain the numerical results because numerical integrals and an infinite simultaneous equation must be also solved. At high frequencies or large square of the cylinder compared with wavelength, these methods are poorly convergent, so that the scattered far-field by small rectangular cylinder is mainly described. For these problems, it is impotant to find the scattered field in the vicinity of the large rectangular cylinder. To solve this problem, we found the new method. The total scattered field by a single semi-infinite conducting wedge is well known, so that the total field in the vicinity of the wedge with semi-infinite half plane can be found. By considering this concept, we find the new solution. The scattered field by the large conducting rectangular cylinder is easily obtained as a superposition of the two or three kinds of the known solution for the single wedge scattering. New numerical results are in good agreement with the conventional results e. g., integral equation. Computing time is also remarkably short compared with conventional ones.

2. A METHOD FOR SOLVING THE SCATTERED FIELD BY THREE WEDGES

A new method for solving the scattered field by two wedge has been already reported by author. For which the scattered field is only valid for the foward scattering. In order to find the scattered field in the entire region, three wedges must be considered. For the single wedge the total diffracted field by line source is given

$$E_x^t = -\frac{\pi\omega\mu}{\Phi_0}\sum_{n=1}^{\infty} H_{\nu_n}^{(2)}(kd)\, J_{\nu_n}(k\rho)\, \sin(\nu_n\phi_s)\, \sin(\nu_n\phi) \qquad (\rho < d) \tag{1}$$

where $\nu_n = \frac{n\pi}{\Phi_0}$, $\Phi_0 = 2\pi - \Phi_w$ and I is the amplitude of the current. For the above expression the picture of the conducting wedge is shown in Fig 1. To obtain the plane wave expression, d goes to infinity. In the case the asymptotic formula for $H_\nu^{(2)}(kd)$ can be used. therefore Eq (1) becomes

$$E_x^t = \frac{4\pi E_0}{\Phi_0} e^{jk\rho_c\cos(\theta_c-\theta_i)} \sum_{n=1}^{\infty} J_{\nu_n}(k\rho)\, e^{j\frac{\nu_n\pi}{2}} \sin(\nu_n\phi_s)\, \sin(\nu_n\phi) \tag{2a}$$

where $$E_0 = \frac{-\omega\mu I}{4}\sqrt{\frac{2}{\pi k\rho_i}}\, e^{-j(k\rho_i - \frac{\pi}{4})} \tag{2b}$$

The incident plane wave in absence of the cylinder is given by

$$E_x^i = E_0\, e^{jk(z\cos\theta_i - y\sin\theta_i)} \tag{2c}$$

As shown in Fig 2, we consider the three kinds of wedge 1, 2 and 3. The total scattered field by rectangular cylinder with length $2a$ and $2b$ can be obtained by combination of the scattered fields wedge 1, 2 and 3. The coordinates for the combination of three wedges are illustrated in Fig 3. From Eq (1) the total scattered fields E_{x_1}, E_{x_2} and E_{x_3} by the wedge 1 (∠LBADM), wedge 2 (∠HABCJ) and wedge 3 (∠FADCG) are, respectively, given

$$E_{x1} = \frac{8E_0}{3} e^{jk\rho_c \cos(\theta_c - \theta_i)} \sum_{n=1}^{\infty} J_{\frac{2n}{3}}(k\rho_1)\, e^{j\frac{n\pi}{3}} \sin(\tfrac{2}{3}n\phi_{s1}) \sin(\tfrac{2}{3}n\phi_1) \quad (3a)$$

$$E_{x2} = \frac{8E_0}{3} e^{-jk\rho_c \cos(\theta_c + \theta_i)} \sum_{n=1}^{\infty} J_{\frac{2n}{3}}(k\rho_2) \sin(\tfrac{2}{3}n\phi_{s2}) \sin(\tfrac{2}{3}n\phi_2) \quad (3b)$$

$$E_{x3} = \frac{8E_0}{3} e^{jk\rho_c \cos(\theta_c + \theta_i)} \sum_{n=1}^{\infty} J_{\frac{2n}{3}}(k\rho_3) \sin(\tfrac{2}{3}n\phi_{s3}) \sin(\tfrac{2}{3}n\phi_3) \quad (3c)$$

where $\phi_{s1} = \pi - \theta_i$, $\phi_{s2} = \frac{3\pi}{2} - \theta_i$, $\phi_{s3} = \pi + \theta_i$,

$\rho_c = \sqrt{a^2+b^2}$, $\theta_c = \tan^{-1}(b/a)$,

$\rho_1 = \sqrt{(z+a)^2+(y-b)^2}$, $\rho_2 = \sqrt{(z-a)^2+(y-b)^2}$, $\rho_3 = \sqrt{(z+a)^2+(y+b)^2}$,

$\phi_1 = \tan^{-1}(\frac{y-b}{z+a})$, $\phi_2 = \frac{\pi}{2} + \tan^{-1}(\frac{y-b}{z-a})$, $\phi_3 = -\tan^{-1}(\frac{y+b}{z+a})$,

$0 \le \phi_1, \ \phi_2, \ \phi_3 < \frac{3\pi}{2}$

Therefore the total scattered field by the rectangular cylinder (□ABCD) can be obtained as a superposition of E_{x1}, E_{x2} and E_{x3} as follows:

$$E^t_{xI} = E_{x1} + E_{x2} + E_{x3} - 2E^i_x - E^{rFM}_x - E_x^{rHL} \quad \text{for the region I} \quad (4a)$$

$$E^t_{x\text{II}a} = E_{x1} + E_{x3} - E^i_x - E^{rFM}_x \quad \text{for the region II-a} \quad (4b)'$$

$$E^t_{x\text{II}b} = E_{x1} + E_{x2} - E^i_x - E^{rHL}_x \quad \text{for the region II-b} \quad (4b)''$$

where

$$E_{x\text{III}} = E_{x1} + E_{x3} \quad \text{for the region III} \quad (4c)$$

$$E^{rFM}_x = - E_0\, e^{2jka\cos\theta_i}\, e^{jk(y\sin\theta_i + z\cos\theta_i)}$$

$$E^{rHL}_x = - E_0\, e^{2jkb\sin\theta_i}\, e^{-jk(y\sin\theta_i + z\cos\theta_i)}$$

The main purpose of this letter is to find the behaviour of the scattered field near the cylinder. A comparison of the amplitude of the scattered field along the y axis is shown in Fig 4, in which the dotted lines are obtained by PMM. Thus the new results are in full agreement with the conventional results. The amplitude of the near field distribution around the large SUNSHINE BUILDING in Tokyo is also illustrated in Fig 5.

Computing time is also very short compared with the conventional results.

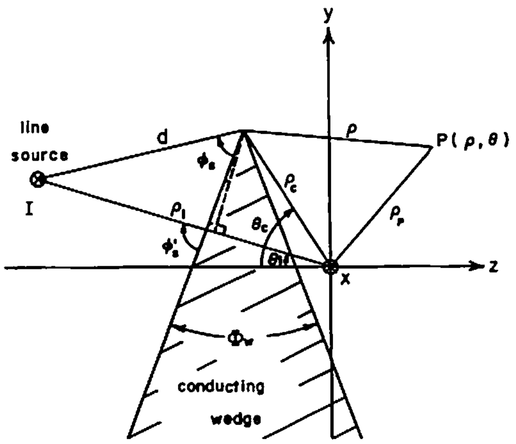

Fig.1 Coordinates of single wedge

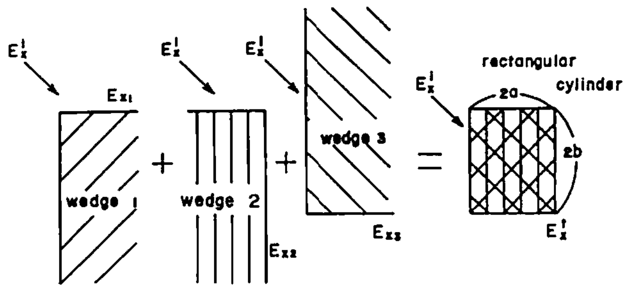

Fig.2 Combination of the three wedges 1, 2 and 3

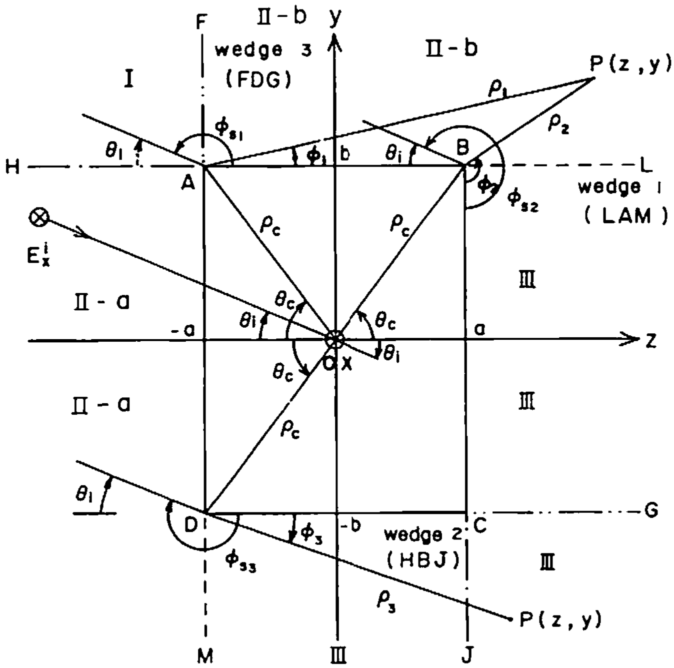

Fig.3 Geometry of the rectangular cylinder with 2a and 2b

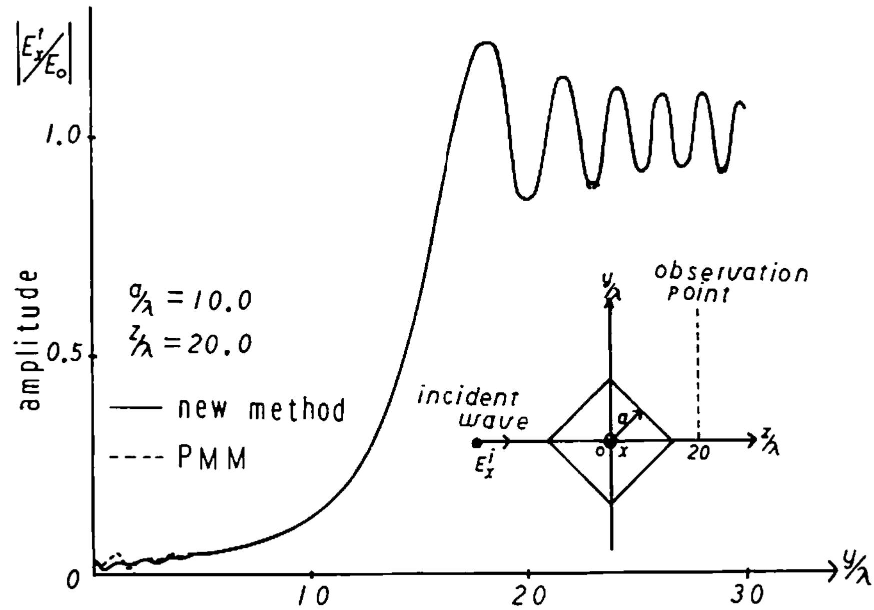

Fig.4 Comparison between new method and PMM

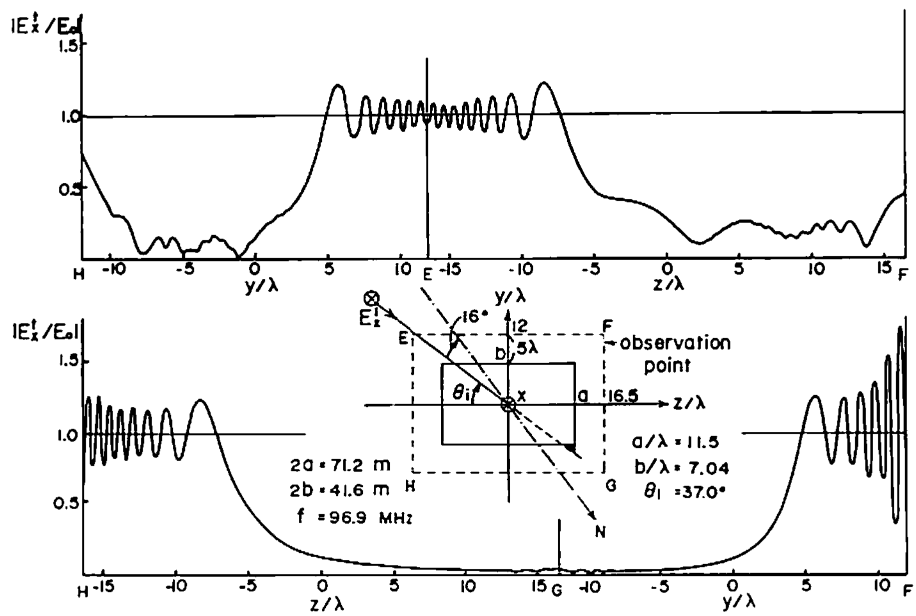

Fig.5 The amplitude of the total scattered field around the large building