Finally, judging from the shape of mean pressure distribution around the surface in the two figures 6, 7, it stands to reason that the present calculation is capable of accurately predicting the pattern or dynamics of flow across tube-banks.

3.3 Drag and lift coefficients

To further validate the present study with experiments, table 2 summarizes the flow parameters concerning $\overline{C}_D$ and C'_L along with experimental measurements. The coefficient of mean drag per unit span is defined by:

$$\overline{C}_D = \frac{\overline{F}_D}{ld\rho u_g^2/2} \tag{26}$$

where l denotes the spanwise length of the cylinder; $\overline{F}_D$ denotes the form drag force caused by the surface pressure distribution through ignoring the viscous drag force, which is obtained by an integration of mean pressure distribution around the cylinder. Thus, $\overline{C}_D$ is given by

$$\overline{C}_D = \int_{0^o}^{180^o} \overline{C}_P cos(\theta) \mathrm{d}\theta. \tag{27}$$

It is evident that the results of $\overline{C}_D$ predicted by the present LES study agree favorably well with the experimental measurements ([27]) except under-predict $\overline{C}_D$ for the second column cylinder; the magnitudes of C'_L obtained from this work shows reasonable agreement with experimentally measured values except for the first column cylinder due to the reason discussed before. The results for $\overline{C}_D$ and C'_L are also interpreted in terms of with the free stream velocity u_o, which is based on the conversion factor discussed in section 3.2 and clearly a significant variable concerning $\overline{C}_D$ and C'_L as shown in table 2. Through interpreting this way, the drag experienced by the first column cylinder is increased considerably. Similar observations apply to the rest of downstream cylinders. But the increment for the first column cylinder is distinct from the remaining ones. Comparing the value $\overline{C}_D = 1.941$ in terms of $Re_g = 15270$ with $\overline{C}_D = 1.185$ ([41]) for a comparable Reynolds number, it can be observed that $\overline{C}_D$ for the first column cylinder predicted in this LES study is considerably higher that the value for a unconfined single smooth circular cylinder. This can be explained that the distinct discrepancy interpreted through u_o is undoubtedly a consequence