In [48]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import os
from IPython.display import display

sns.set(font_scale=1.5)
```

In [294]:
```
def parse_file(df, path, group, file):
    full_path = path + '/' + file
    known_lb = 0
    known_ub = 0
    negative_weight = 0
    collected = {}
    with open(full_path, 'r') as f:
        for line in f:
            key, value = line.split(':')

            if key.startswith('Known lower'):
                known_lb = int(value)
                continue
            if key.startswith('Known upper'):
                known_ub = int(value)
                continue
            if key.startswith('Negative'):
                negative_weight = int(value)
                continue

            algo = ''
            if key.startswith('Brute'):
                algo = 'bruteforce'
            elif key.startswith('Rand'):
                algo = 'random'
            elif key.startswith('Greed'):
                algo = 'greed'
            elif key.startswith('Goemans'):
                algo = 'goemans-williamson'

            if algo not in collected:
                collected[algo] = [0, 0]

            if key.endswith('(answer)'):
                collected[algo][0] = int(value)
                known_lb = max(known_lb, int(value))
            else:
                collected[algo][1] = float(value)
    for algo, (ans, time) in collected.items():
        group_name = group
        if 'biqmac' in group:
            group_name = group + '/' + file[:-2]
        df.loc[len(df)] = [
```

```
            group_name, algo, ans, time, known_lb, known_ub, ne
        ]


def parse_results(path='../testing/results'):
    df = pd.DataFrame(columns=[
        'group', 'algo', 'weight', 'time', 'known_lower_bound',
        'known_upper_bound', 'negative_weight', 'filename'
    ])
    for root, dirs, files in os.walk(path):
        if not files:
            continue
        dir_name = root.split('results/')[-1]
        for file in files:
            parse_file(df, root, dir_name, file)
    return df


def add_solutions(df, solutions_file):
    with open(solutions_file, 'r') as f:
        for line in f:
            line = line.strip()
            if line != '':
                file, ans = line.split(' ')
                ans = int(ans)
                ind = df[df['filename'] == file].index
                df.loc[ind, 'known_lower_bound'] = ans
```

In [340]:

```
def accumulate_results(all_results):
    df = pd.DataFrame(columns=[
        'group', 'algo', 'mean_time', 'mean_accuracy_lb', 'mean
    ])
    for group_name, group_results in all_results.groupby('group
        for algo_name, table in group_results.groupby('algo'):
            df.loc[len(df)] = [
                group_name, algo_name,
                table.time.mean(),
                table.accuracy_lb.mean(),
                table.accuracy_ub.mean()
            ]
    return df
```

In [346]:
```
all_results = parse_results()
all_results.head()
```

Out[346]:

	group	algo	weight	time	known_lower_bound	known_up
0	random_graph_weights/weight-1000	greed	697534	0.00034	697840	
1	random_graph_weights/weight-1000	goemans-williamson	697840	0.33872	697840	
2	random_graph_weights/weight-1000	greed	702975	0.00030	704340	
3	random_graph_weights/weight-1000	goemans-williamson	704340	0.36708	704340	
4	random_graph_weights/weight-1000	greed	725055	0.00047	725055	

In [347]:
```
add_solutions(all_results, '../testing/tests/biqmac/solutions/i
add_solutions(all_results, '../testing/tests/biqmac/solutions/r
```

In [348]:
```
all_results['accuracy_lb'] = \
    (all_results['weight'] - all_results['negative_weight']) /
        (all_results['known_lower_bound'] - all_results['negati
all_results['accuracy_ub'] = \
    all_results['weight'] / all_results['known_upper_bound']
```

In [349]:
```
results = accumulate_results(all_results)
results.head()
```

Out[349]:

	group	algo	mean_time	mean_accuracy_lb	mean_accuracy_ub
0	biqmac/ising/ising2.5-100_5555	goemans-williamson	0.27099	0.993725	0.354846
1	biqmac/ising/ising2.5-100_5555	greed	0.00061	0.993900	0.355094
2	biqmac/ising/ising2.5-100_6666	goemans-williamson	0.39158	0.993726	0.344382
3	biqmac/ising/ising2.5-100_6666	greed	0.00053	0.995010	0.346923
4	biqmac/ising/ising2.5-100_7777	goemans-williamson	0.35093	0.977962	0.379060

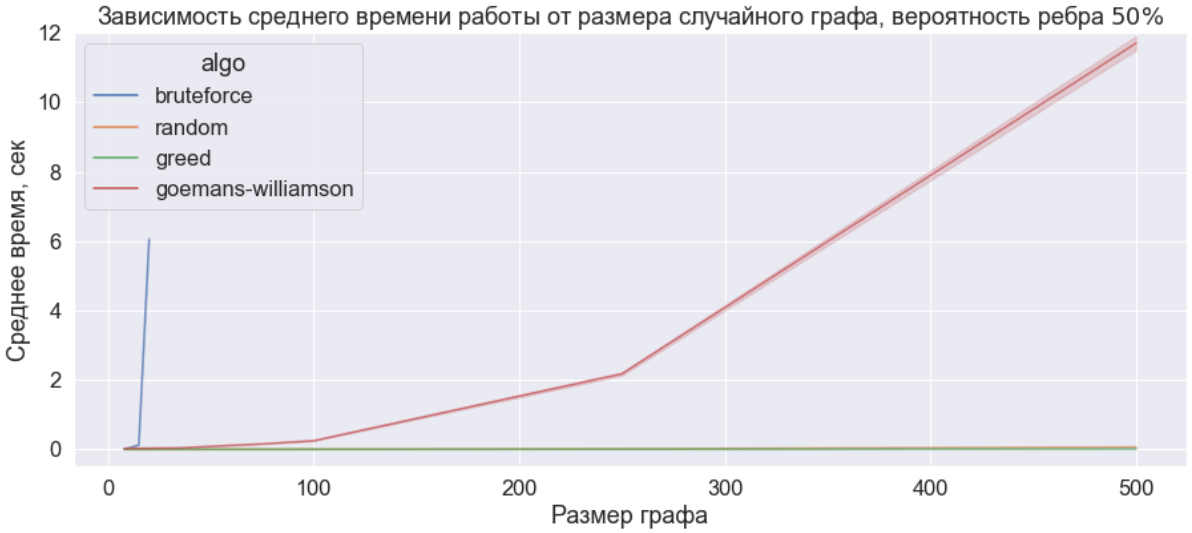
In [355]:

```
def plot_stats_in_group(df, name_filter, param, title=None,
                        xlabel=None, ylabel=None, xlim=None, yl
                        add_theoretical_est=False,
                        xlogscale=False):
    with sns.axes_style('darkgrid'):
        plt.figure(figsize=(15, 6))
        sns.lineplot(data=df,
                     x=df['group'].apply(name_filter),
                     y=df[param].astype(np.float),
                     hue='algo',
                     alpha=0.7)
        if add_theoretical_est:
            xmin = df['group'].apply(name_filter).min()
            xmax = df['group'].apply(name_filter).max()
            plt.hlines(0.87856, xmin=xmin, xmax=xmax,
                       linestyle='--', color='black',
                       alpha=0.7,
                        label=r'Теоретическая оценка $88\%$')
            plt.legend()
        if xlogscale:
            plt.xscale('log')
        plt.xlim(xlim)
        plt.ylim(ylim)
        if title is not None:
            plt.title(title)
        if xlabel is not None:
            plt.xlabel(xlabel)
        if ylabel is not None:
            plt.ylabel(ylabel)
```

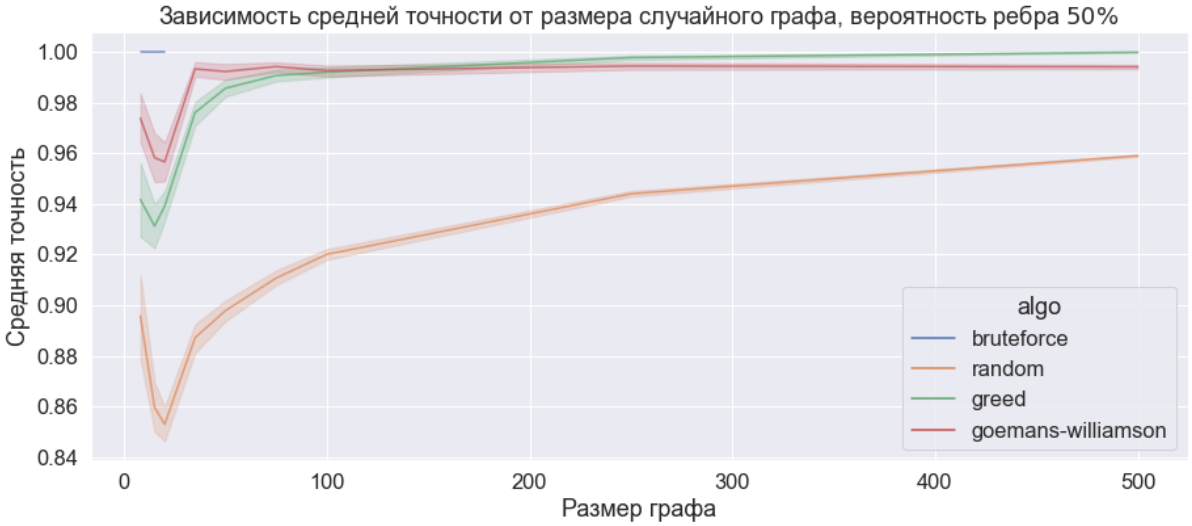
In [353]:

```
def plot_accuracy(df, name_filter, title=None,
                          xlabel=None, ylabel=None, xlim=None, yl
    with sns.axes_style('whitegrid'):
        plt.figure(figsize=(15, 10))
        all_x = df['group'].apply(name_filter)
        x_min = all_x.min()
        x_max = all_x.max()
        for algo in df.algo.unique():
            data = []
            x = df[df['algo'] == algo]['group'].apply(name_filt
            y_min = df[df['algo'] == algo]['mean_accuracy_lb']
            y_max = df[df['algo'] == algo]['mean_accuracy_ub']
            data = list(zip(x, y_min, y_max))
            data.sort(key=lambda x: x[0])
            x = list([d[0] for d in data])
            y_min = list([d[1] for d in data])
            y_max = list([d[2] for d in data])

            plt.fill_between(x, y_min, y_max, label=algo, alpha

        plt.hlines(0.87856, xmin=x_min, xmax=x_max, linestyle='
                   label=r'Теоретическая оценка $88\%$')


        plt.xlim(xlim)
        plt.ylim(ylim)

        plt.legend(loc='lower left')
        if title is not None:
            plt.title(title)
        if xlabel is not None:
            plt.xlabel(xlabel)
        if ylabel is not None:
            plt.ylabel(ylabel)
```

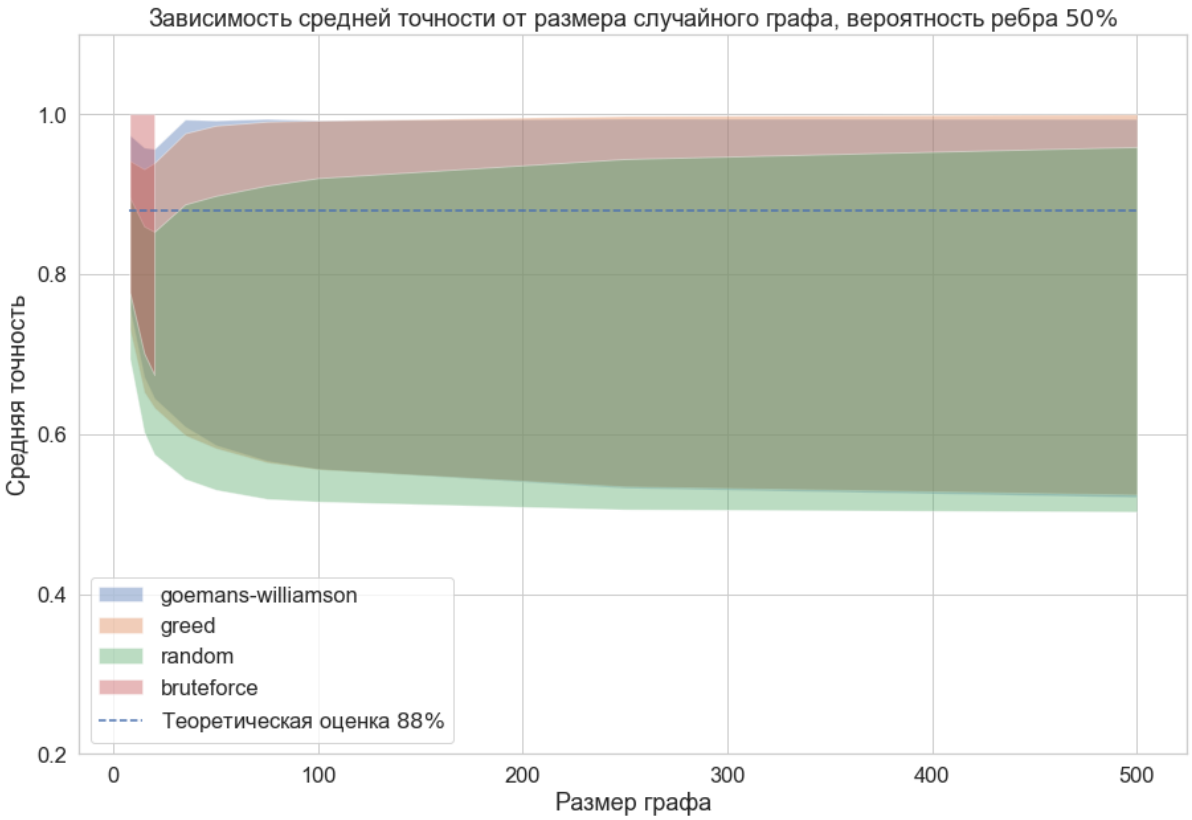
In [363]:
```
plot_stats_in_group(all_results[all_results['group'].str.contai
                    lambda x: int(x.split('/')[-1].split('-')[-
                    'time',
                    title='Зависимость среднего времени работы
                    'от размера случайного графа, '
                    r'вероятность ребра $50\%$',
                    xlabel='Размер графа',
                    ylabel='Среднее время, сек',
                    ylim=(-0.5, 12))
plt.savefig('graphics/random_graph_50_time')
```



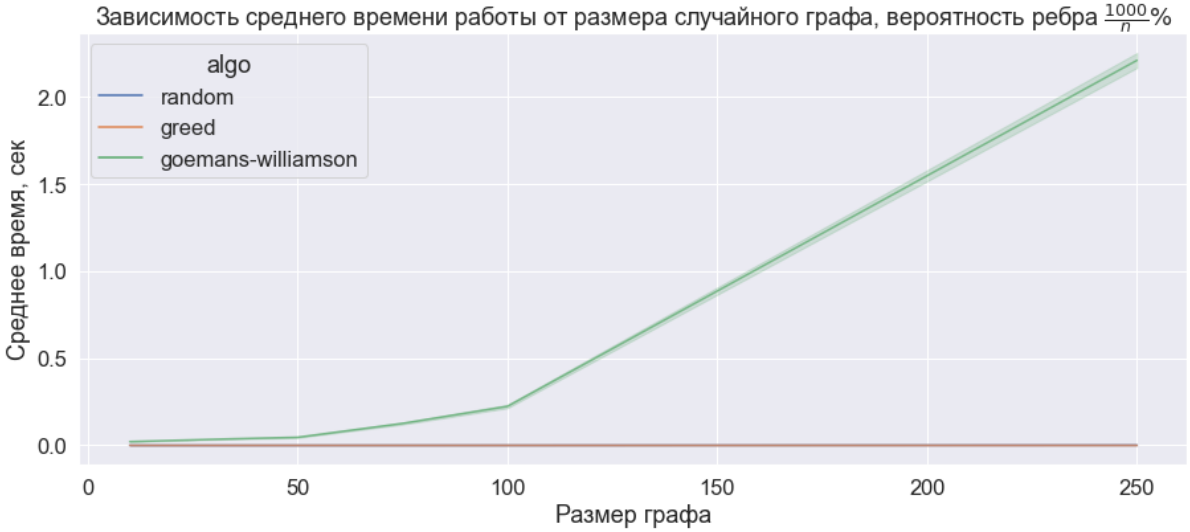
In [364]:
```
plot_stats_in_group(all_results[all_results['group'].str.contai
                    lambda x: int(x.split('/')[-1].split('-')[-
                    'accuracy_lb',
                    title='Зависимость средней точности '
                    'от размера случайного графа, '
                    r'вероятность ребра $50\%$',
                    xlabel='Размер графа',
                    ylabel='Средняя точность')
plt.savefig('graphics/random_graph_50_accuacy')
```



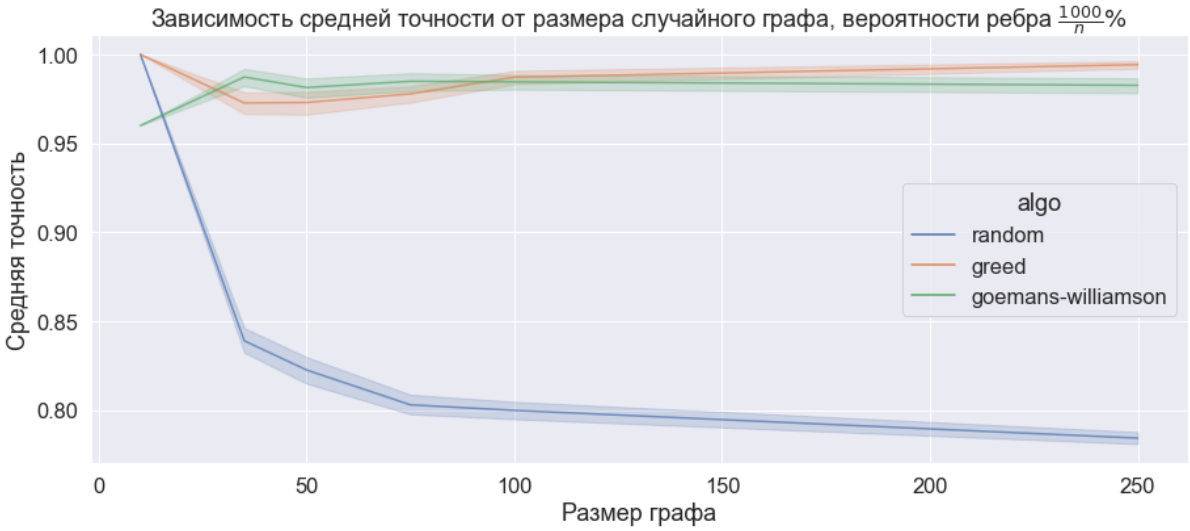
In [365]:
```
plot_accuracy(results[results['group'].str.contains('random_gra
                      lambda x: int(x.split('/')[-1].split('-')[-
                      title='Зависимость средней точности '
                      'от размера случайного графа, '
                      r'вероятность ребра $50\%$',
                      xlabel='Размер графа',
                      ylabel='Средняя точность',
                      ylim=(0.2, 1.1))
plt.savefig('graphics/random_graph_50_accuacy_lu')
```



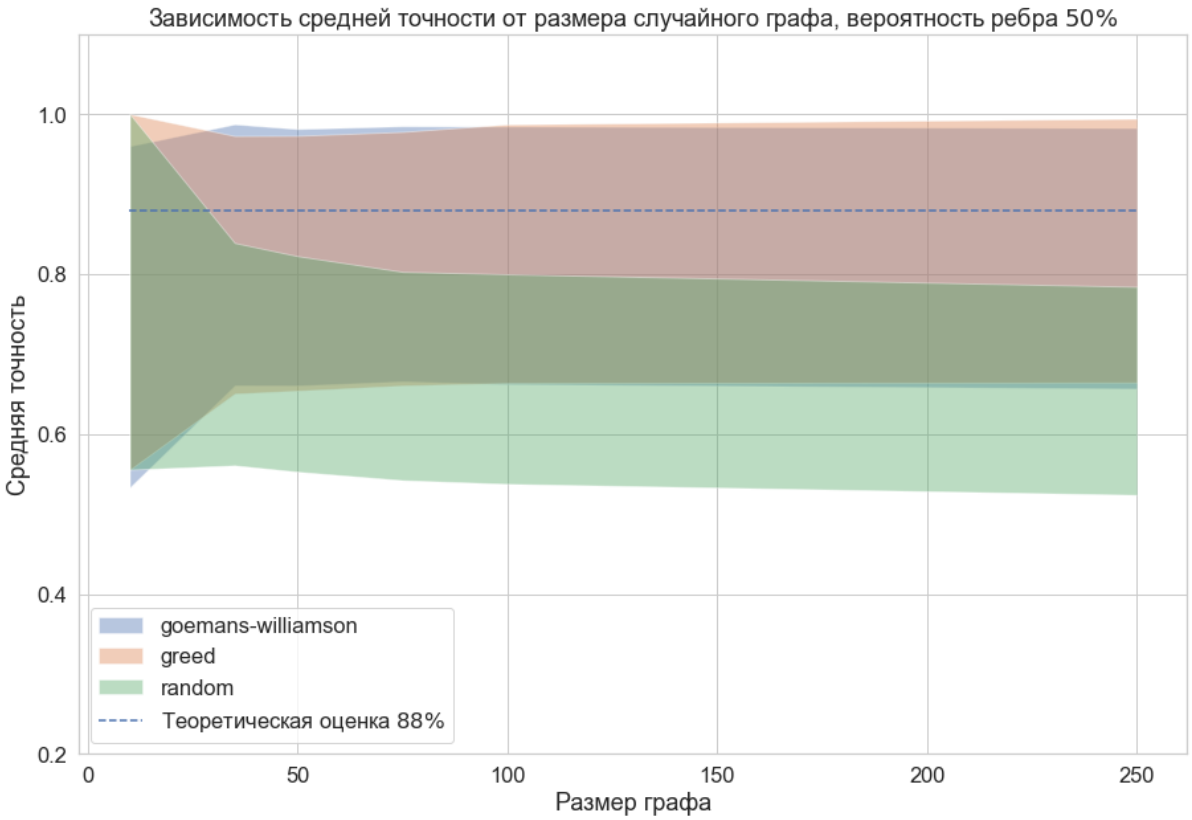
In [366]:
```
plot_stats_in_group(all_results[all_results['group'].str.contai
                    lambda x: int(x.split('/')[-1].split('-')[-
                    'time',
                    title='Зависимость среднего времени работы
                    'от размера случайного графа, '
                    r'вероятность ребра $\frac{1000}{n}\%$',
                    xlabel='Размер графа',
                    ylabel='Среднее время, сек')
plt.savefig('graphics/random_graph_10n_time')
```



In [367]:
```
plot_stats_in_group(all_results[all_results['group'].str.contai
                    lambda x: int(x.split('/')[-1].split('-')[-
                    'accuracy_lb',
                    title='Зависимость средней точности '
                    'от размера случайного графа, '
                    r'вероятности ребра $\frac{1000}{n}\%$',
                    xlabel='Размер графа',
                    ylabel='Средняя точность')
plt.savefig('graphics/random_graph_10n_accuracy')
```



In [368]:
```
plot_accuracy(results[results['group'].str.contains('random_gra
                      lambda x: int(x.split('/')[-1].split('-')[-
                      title='Зависимость средней точности '
                      'от размера случайного графа, '
                      r'вероятность ребра $50\%$',
                      xlabel='Размер графа',
                      ylabel='Средняя точность',
                      ylim=(0.2, 1.1))
plt.savefig('graphics/random_graph_10n_accuracy_lu')
```

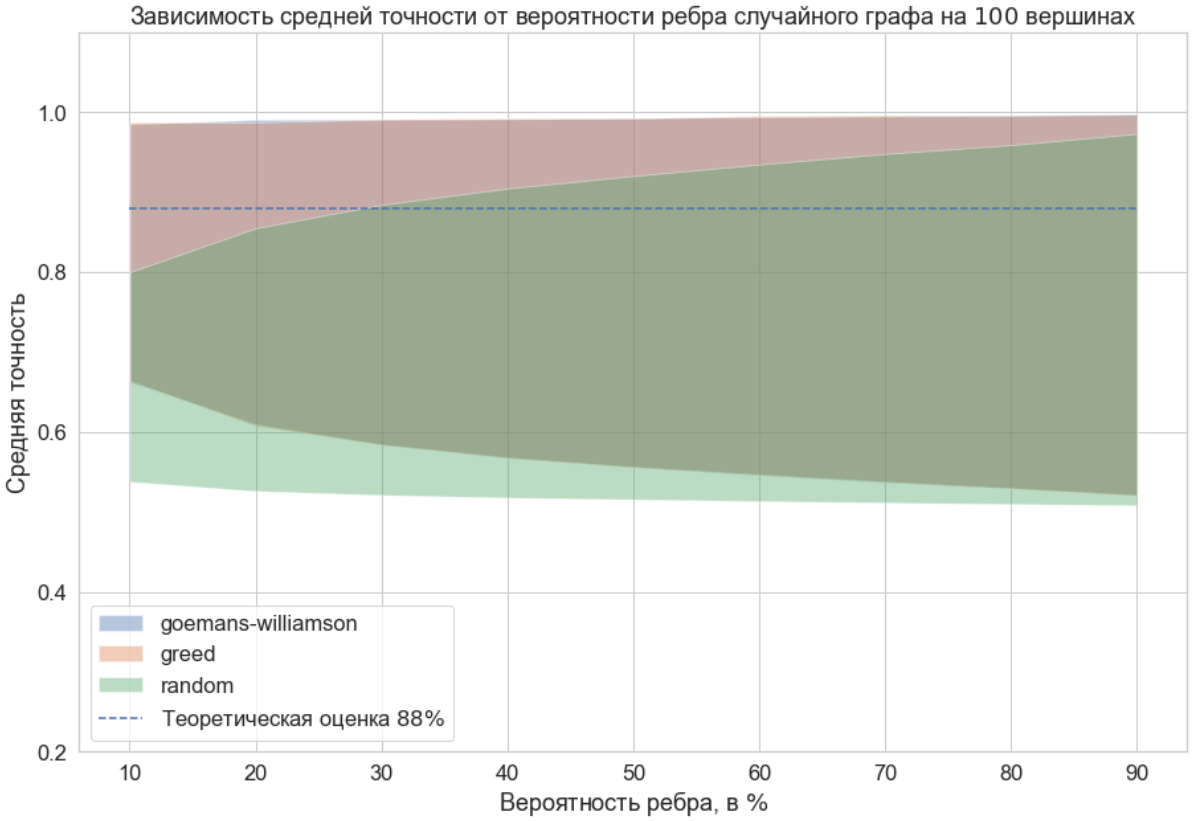


In [369]:

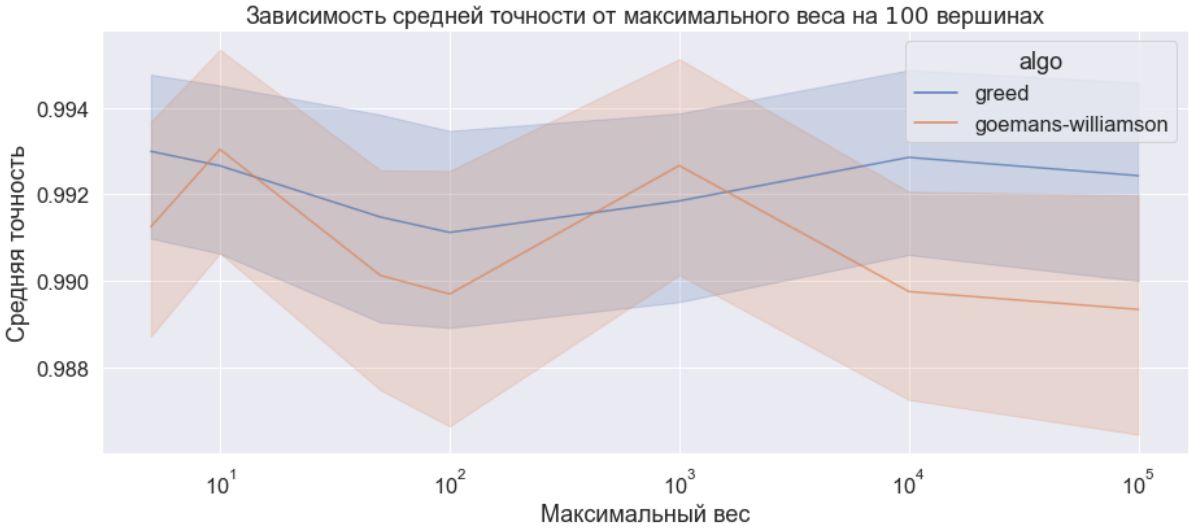
```
plot_stats_in_group(all_results[all_results['group'].str.contai
                    lambda x: int(x.split('/')[-1].split('-')[-
                    'accuracy_lb',
                    title='Зависимость средней точности '
                    'от вероятности ребра случайного графа '
                    r'на $100$ вершинах',
                    xlabel=r'Вероятность ребра, в $\%$',
                    ylabel='Средняя точность')
plt.savefig('graphics/random_graph_prob_accuracy')
```

In [370]:

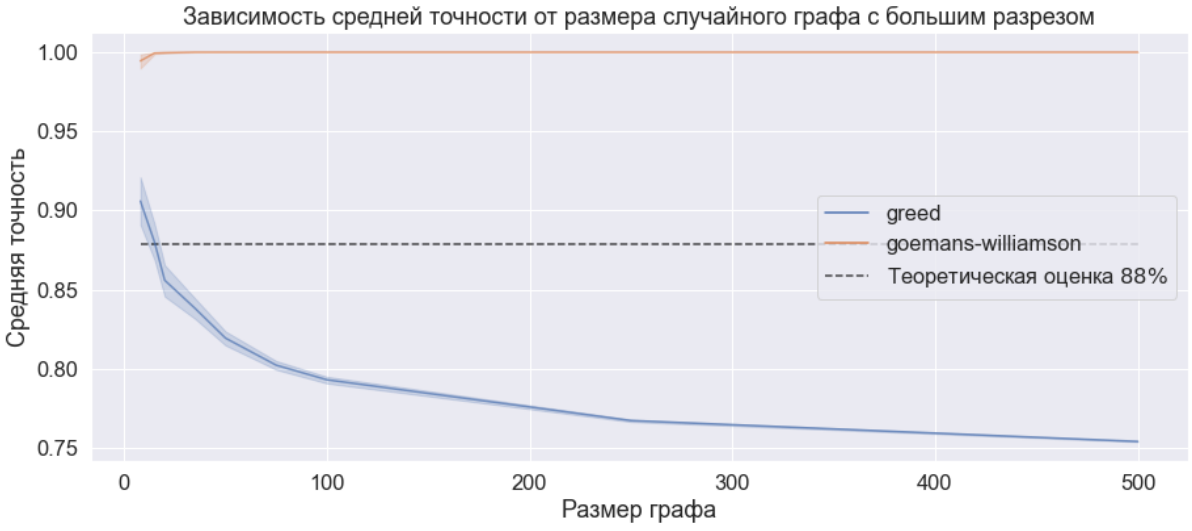
```
plot_accuracy(results[results['group'].str.contains('random_gra
                      lambda x: int(x.split('/')[-1].split('-')[-
                      title='Зависимость средней точности '
                      'от вероятности ребра случайного графа '
                      r'на $100$ вершинах',
                      xlabel=r'Вероятность ребра, в $\%$',
                     ylabel='Средняя точность',
                      ylim=(0.2, 1.1))
plt.savefig('graphics/random_graph_prob_accuracy_lu')
```



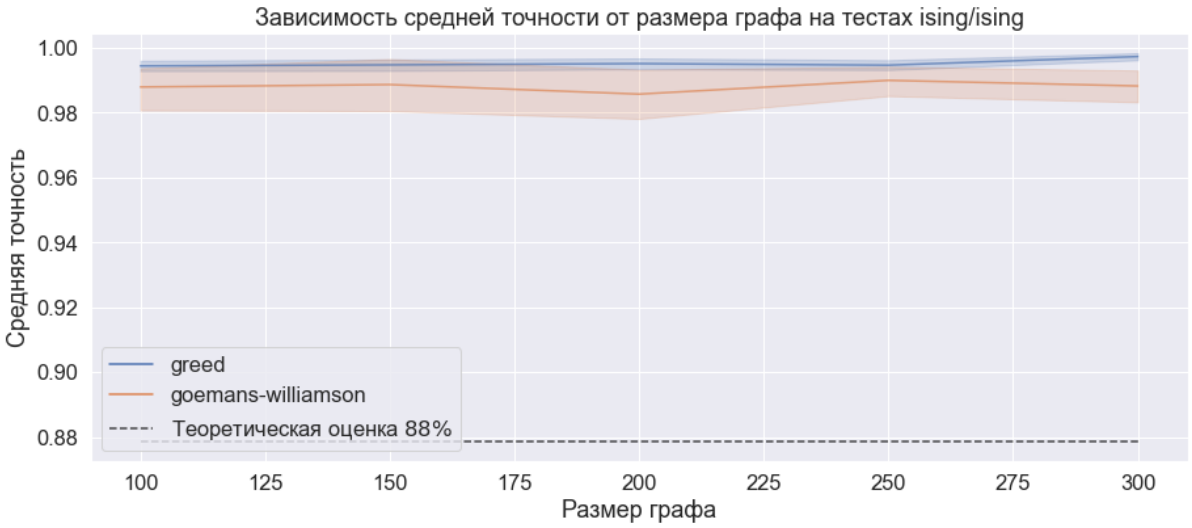
In [371]:
```
plot_stats_in_group(all_results[all_results['group'].str.contai
                    lambda x: int(x.split('/')[-1].split('-')[-
                    'accuracy_lb',
                    title='Зависимость средней точности '
                    'от максимального веса '
                    r'на $100$ вершинах',
                    xlabel=r'Максимальный вес',
                    ylabel='Средняя точность',
                    xlogscale=True)
plt.savefig('graphics/random_graph_weights_accuracy')
```



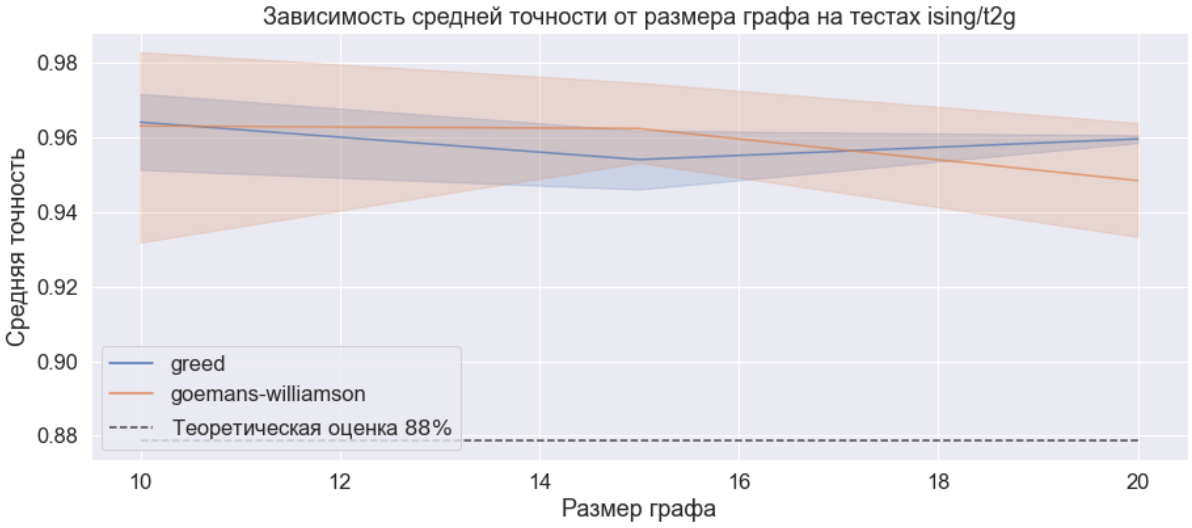
In [372]:
```
plot_stats_in_group(all_results[all_results['group'].str.contai
                    lambda x: int(x.split('/')[-1].split('-')[-
                    'accuracy_lb',
                    title='Зависимость средней точности '
                    'от размера случайного графа '
                    r'с большим разрезом',
                    xlabel='Размер графа',
                    ylabel='Средняя точность',
                    add_theoretical_est=True)
plt.savefig('graphics/large_cut_accuracy')
```



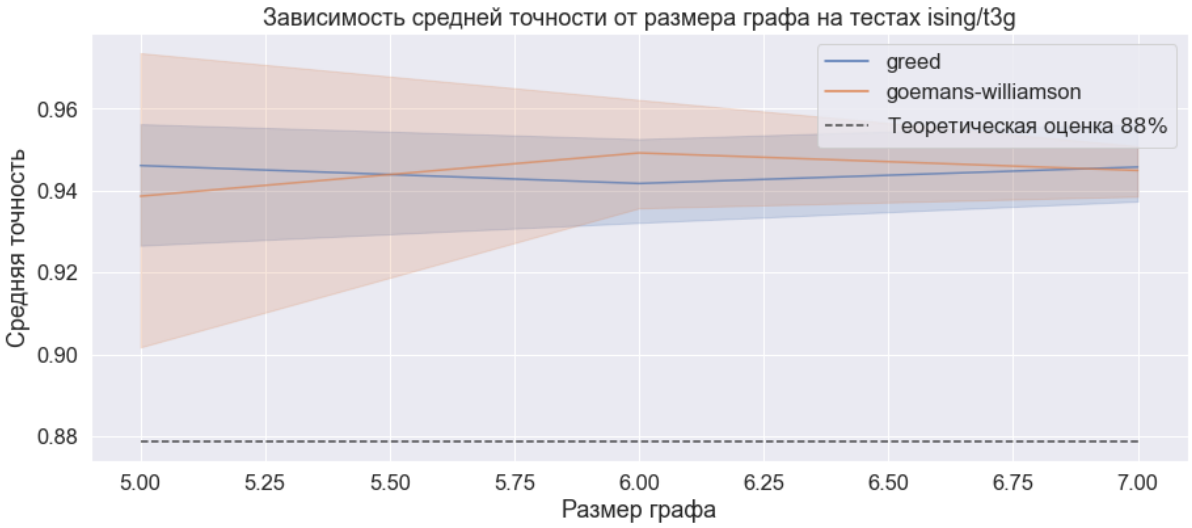
In [373]:
```
plot_stats_in_group(all_results[all_results['group'].str.contai
                    lambda x: int(x.split('/')[-1].split('-')[-
                    'accuracy_lb',
                    title='Зависимость средней точности '
                    'от размера графа '
                    r'на тестах ising/ising',
                    xlabel=r'Размер графа',
                    ylabel='Средняя точность',
                    add_theoretical_est=True)
plt.savefig('graphics/ising_ising_accuracy')
```



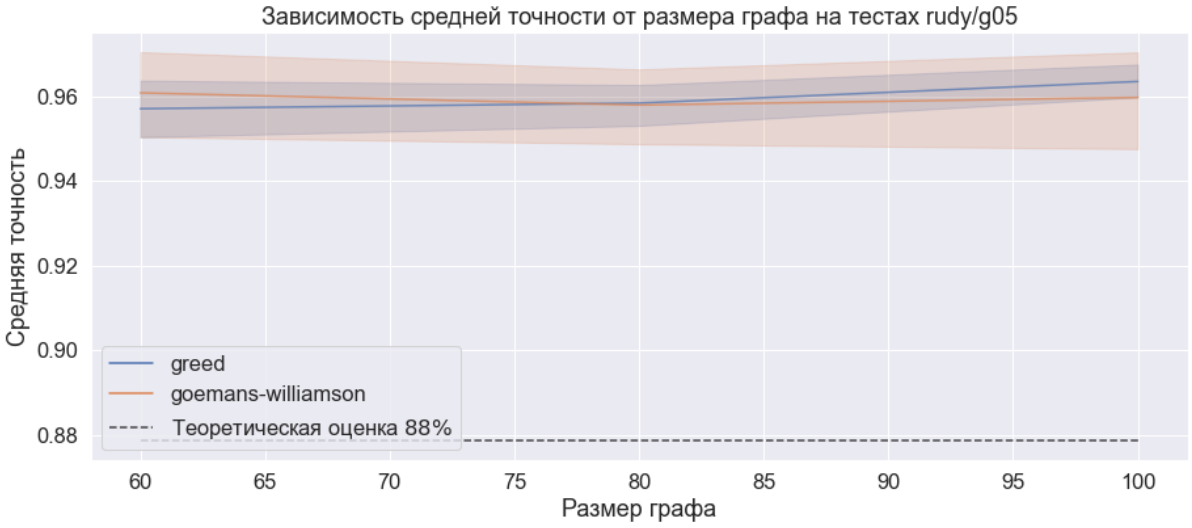
In [374]:
```
plot_stats_in_group(all_results[all_results['group'].str.contai
                    lambda x: int(x.split('/')[-1].split('_')[0
                    'accuracy_lb',
                    title='Зависимость средней точности '
                    'от размера графа '
                    r'на тестах ising/t2g',
                    xlabel=r'Размер графа',
                    ylabel='Средняя точность',
                    add_theoretical_est=True)
plt.savefig('graphics/ising_t2g_accuracy')
```



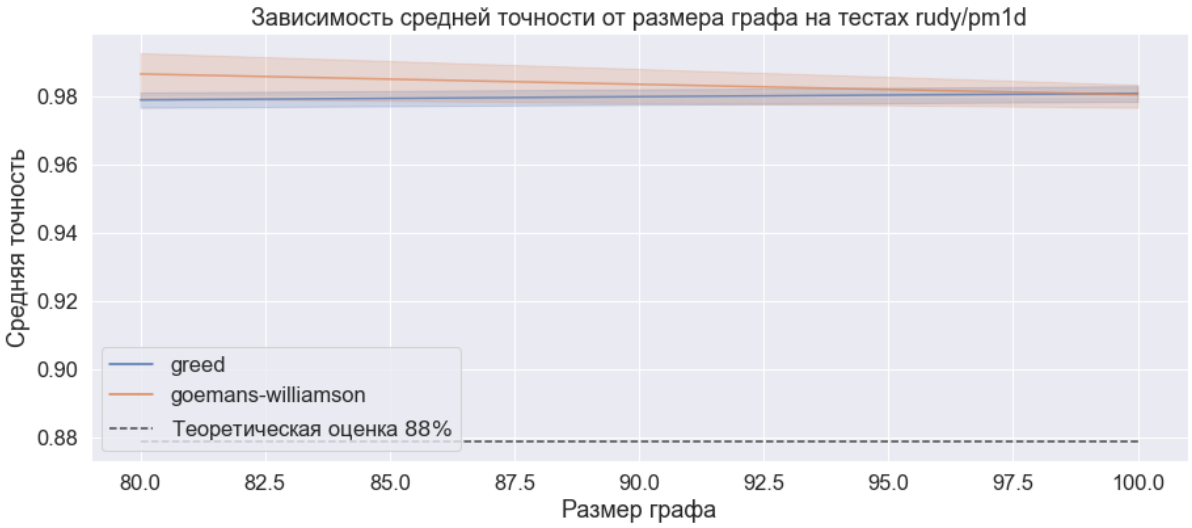
In [375]:
```
plot_stats_in_group(all_results[all_results['group'].str.contai
                    lambda x: int(x.split('/')[-1].split('_')[0
                    'accuracy_lb',
                    title='Зависимость средней точности '
                    'от размера графа '
                    r'на тестах ising/t3g',
                    xlabel=r'Размер графа',
                    ylabel='Средняя точность',
                    add_theoretical_est=True)
plt.savefig('graphics/ising_t3g_accuracy')
```



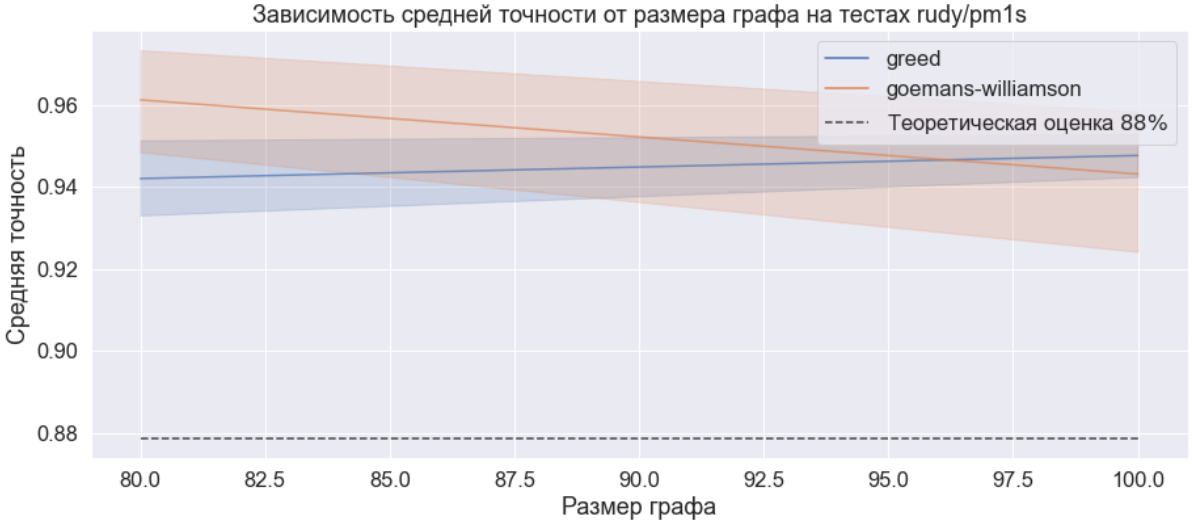
In [376]:
```
plot_stats_in_group(all_results[all_results['group'].str.contai
                    lambda x: int(x.split('/')[-1].split('_')[1
                    'accuracy_lb',
                    title='Зависимость средней точности '
                    'от размера графа '
                    r'на тестах rudy/g05',
                    xlabel=r'Размер графа',
                    ylabel='Средняя точность',
                    add_theoretical_est=True)
plt.savefig('graphics/rudy_g05_accuracy')
```



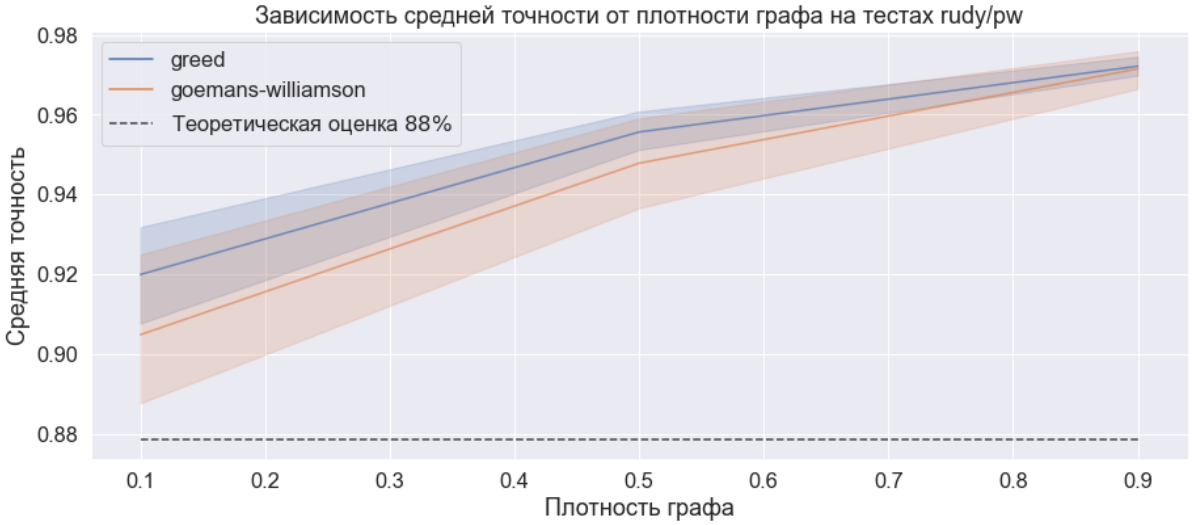
In [382]:
```
plot_stats_in_group(all_results[all_results['group'].str.contai
                    lambda x: int(x.split('/')[-1].split('_')[1
                    'accuracy_lb',
                    title='Зависимость средней точности '
                    'от размера графа '
                    r'на тестах rudy/pm1d',
                    xlabel=r'Размер графа',
                    ylabel='Средняя точность',
                    add_theoretical_est=True)
plt.savefig('graphics/rudy_pm1d_accuracy')
```



In [381]:
```
plot_stats_in_group(all_results[all_results['group'].str.contai
                    lambda x: int(x.split('/')[-1].split('_')[1
                    'accuracy_lb',
                    title='Зависимость средней точности '
                    'от размера графа '
                    r'на тестах rudy/pm1s',
                    xlabel=r'Размер графа',
                    ylabel='Средняя точность',
                    add_theoretical_est=True)
plt.savefig('graphics/rudy_pm1s_accuracy')
```



In [378]:
```
plot_stats_in_group(all_results[all_results['group'].str.contai
                    lambda x: int(x.split('/')[-1].split('_')[0
                    'accuracy_lb',
                    title='Зависимость средней точности '
                    'от плотности графа '
                    r'на тестах rudy/pw',
                    xlabel=r'Плотность графа',
                    ylabel='Средняя точность',
                    add_theoretical_est=True)
plt.savefig('graphics/rudy_pw_accuracy')
```



In [379]:
```
plot_stats_in_group(all_results[all_results['group'].str.contai
                    lambda x: int(x.split('/')[-1].split('_')[0
                    'accuracy_lb',
                    title='Зависимость средней точности '
                    'от плотности графа '
                    r'на тестах rudy/w',
                    xlabel=r'Плотность графа',
                    ylabel='Средняя точность',
                    add_theoretical_est=True)
plt.savefig('graphics/rudy_w_accuracy')
```